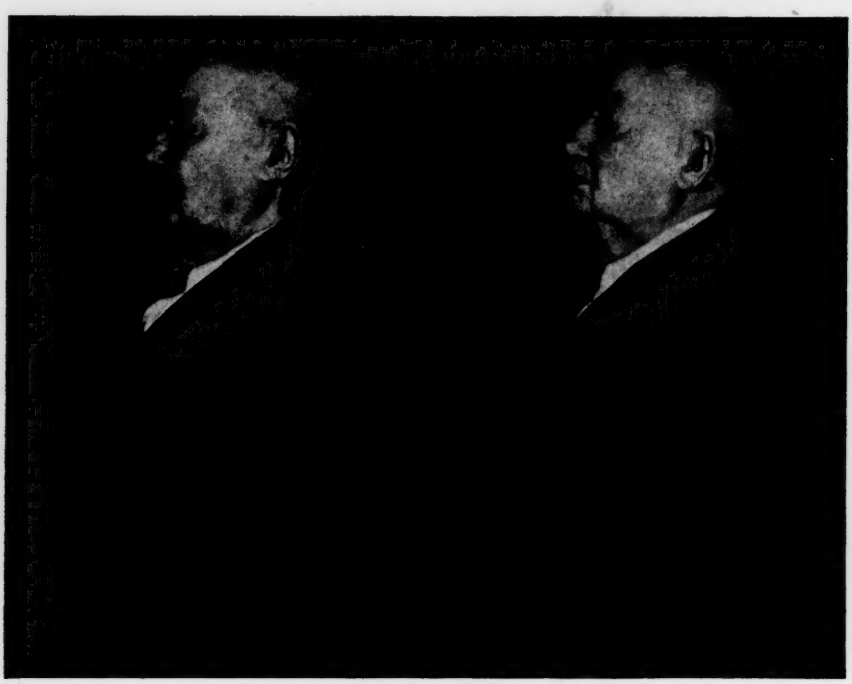
The Journal of HEREDITY



WHICH TWIN SPEAKS ENGLISH?
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The Denver Conservation Congress

A Fertile Polyhaploid Brome Grass

The Bucks County Holstein Quintuplets

Two Pedigrees of Missing Incisors

VOLUME 39 DECEMBER, 1948 NUMBER 12

The American Genetic Association

An incorporated organization devoted to promoting a knowledge of the laws of heredity and their application to the improvement of plants, animals, and human racial stocks

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The

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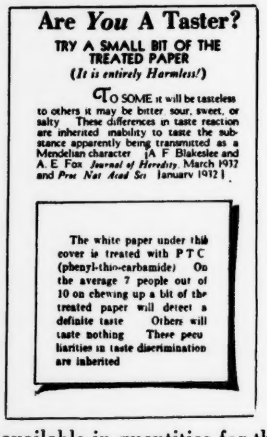
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The white paper under this cover is treated with P T C (phenyl-thio-carbamide) On the average 7 people out of 10 on chewing up a bit of the treated paper will detect a definite taste Others will taste nothing These peculiarities in taste discrimination are inherited

LEAFLETS TO DEMONSTRATE HEREDITY

Last year the "Taster test" served as an introduction to human genetic differences in many classrooms. The test is so easily made with the treated paper, and arouses such great interest that it appears to have a definite place in group demonstrations of such differences. These leaflets, size 3⅜" by 5½", are available in quantities for those who wish to use them for classroom or lecture purposes. On the back is printed an outline 4-generation pedigree chart. Sample on request. Prices: 10 for 25c; 50 for $1.00.

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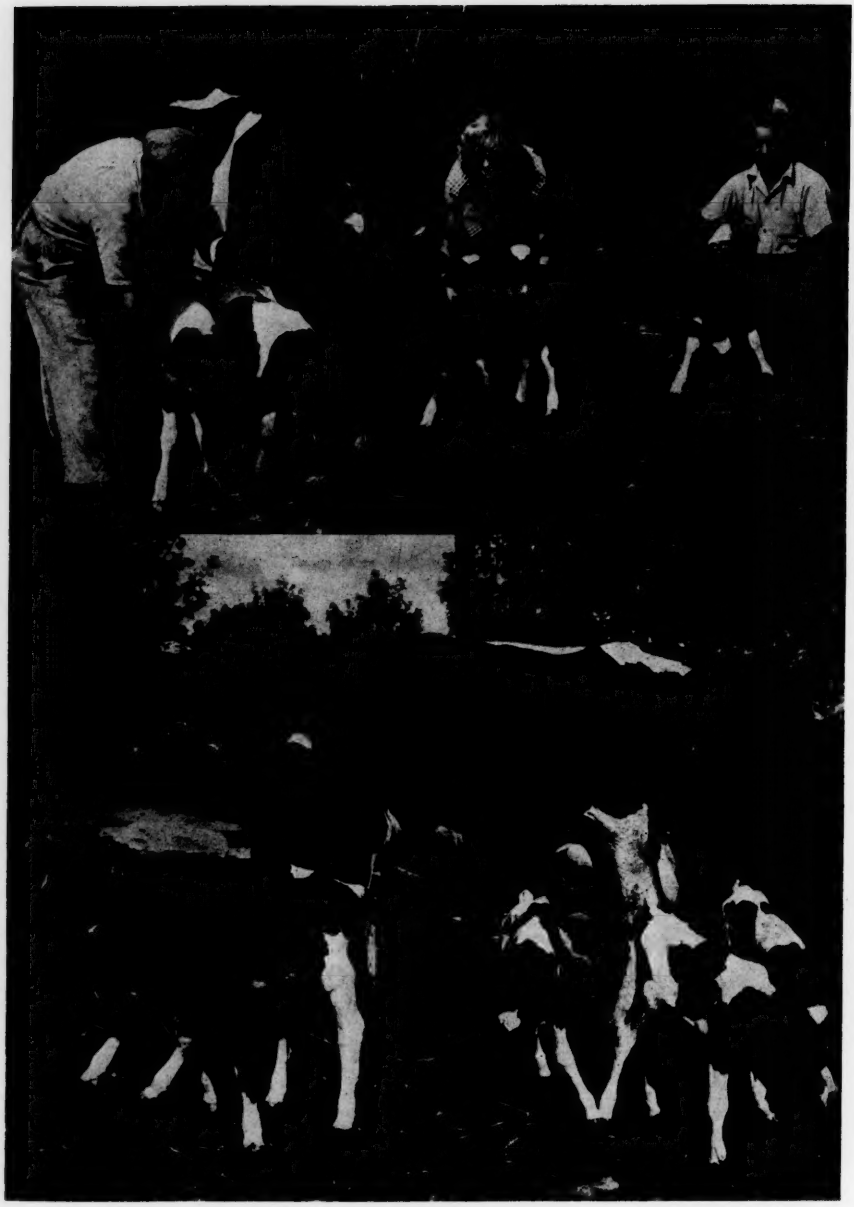

BOVINE DIONNES

Figure 1

Mrs. Eliassen's eleven-year-old Holstein cow "Daisy" made history when she gave birth to five calves one fine night in August, 1948. The quintuplets appear to be made up of a set of identical twins and of (probably) identical triplets. The "twins" are at the left in the lower photo and in the center in the upper photo. Photographs by Donald L. Riley, Easton, Penna.

THE BUCKS COUNTY QUINTUPLETS

THE fields of editorial interest of *The New Yorker* magazine and the JOURNAL OF HEREDITY rarely overlap. A recent phenomenon of nature resulted in an unprecedented cooperative expedition on the part of the editorial staffs of these two publications. The September 18 issue of *The New Yorker* contained an account of a visit to the Holstein Dionnes of Durham, Pennsylvania. The quints were born to a cow named "Daisy" one fine night in August on the farm of Mrs. Ada Eliassen. Daisy is ten years old and has had several previous calves, all of them single. Mrs. Eliassen herself is a widow with eleven children, none of them twins. The ground of the Eliassen farm seems to burgeon with fecundity.

Shortly after the publication of this note, *The New Yorker* addressed the JOURNAL OF HEREDITY an inquiry regarding earlier cases and frequency of multiple births in cattle. Out of this came a suggestion from *The New Yorker* that "your placental leg-man ought to visit this case in person." And on October 22 the opposite numbers in the placental departments of the two publications set forth from New York to Durham, Penna., to visit the quints.

Mrs. Eliassen's farm is about eight miles south of Easton, Penna. We had no difficulty finding it, for the phenomenal birth evidently had shaken the neighborhood and the Eliassen farm was famous. It was raining when we arrived, and the quints were in the barn. The inclement weather made it impossible to move them into the open for detailed photographs of coat patterns, but the two photographs accompanying this note were fortunately available. From these it is possible to check the conclusions of the cooperating experts regarding the zygosity of the quints.

Females, but not Identical

The quints resemble their human contemporaries, the Dionnes, in all being females. They also resemble them in having the names Marie, Cecile, Yvonne, Emily and Annette. They differ in being derived from more than one egg. Two are predominantly black with a white star on the forehead, a mark shared by all five calves. The other three have a much larger area of white.

There is little question that the darker pair are identical twins. The white spotting on the rear of the body represents almost a perfect mirror image pattern. The pattern of white and black on the legs also shows a mirrored asymmetry.

The other three calves appear also to be from a single zygote, even though the spotting-pattern of the three is not as similar as that of the dark "twins." The "triplets" resemble the "twins" in having the forepart of their bodies predominantly black; but in the "triplets" the rear half of the coat is predominantly white. All three "triplets" have a large black spot located asymmetrically over the back and hips. In two of them, this pigmented area includes the base of the tail. In the other the tail is entirely white, which appears to set this individual apart from her two "sisters." This individual with the white tail has a solid pigmented band over the back, in which respect she much more closely resembles one of the two "triplets" whose tails are alike. Other intercomparisons between these three do not clearly set one of the trio apart from the other two. The differences in pattern of all three are of the kind that are found on two sides of the same individual. Hence it seems probable that the "litter" of five is made up of one pair of identical twins and one set of identical triplets.

The sire of this phenomenal litter was a young bull sold to the butcher last spring. The dam is a typical Holstein with a medium amount of spotting.

Frequency of Bovine Twinning

Living quintuplet calves are extremely rare. In 1945, we had a report in the JOURNAL of the "big five" quintuplets born near Ft. Wayne, Indiana. A stillborn set in Germany some years ago is

cited by the veterinarian attending the case as the only other recorded set.

Not a great deal of information is available regarding frequency of multiple births in cattle. The largest collection of data concerns the two beef breeds, Herefords and Aberdeen-Angus. Jones and Rouse[1] reported the following frequencies:

	Total number of births	— Number of sets of — twins	triplets	quadruplets
Herefords	520,900	2,387	5	1
Aberdeen-Angus	299,200	902	2	0

This rate of multiple births figures out to about 4 sets of twins per thousand births and (pooling the total of both breeds) not even one quintuplet birth in three-quarters of a million. The frequencies in these two breeds do not differ greatly. If the ratio between quadruplets and quintuplets were approximately the same as that between triplets and quadruplets (and the difference would probably be much greater) we might hazard the guess that quintuplets would occur with a frequency of not less than one in three to five million births.

Available data regarding dairy cattle are not based on such large samples. Johannson[2] reported in Friesian cattle that of 12,833 births, 424 were twins, two were triplets and one was quadruplets. This is a twin rate of 3 per cent, nearly ten times that in the beef breeds. Twins were reported in just over 3 per cent of births in Holsteins by Lamb[3] in a small sample, confirming that Holsteins in America behave much like their European cousins. Lush[4] reported a Holstein herd in which the twinning rate in 181 births was 8.84 per cent. The evidence is convincing that the dairy herds, and notably the Holsteins, have a higher frequency of twinning than the beef breeds.

It is generally agreed that the twinning frequency increases with the age of the cow. Jones and Rouse found that in the United States the twinning rate was 1.8 per thousand births among two-year old cows, to 7.2 per cent per thousand births in twelve-year old cows. Mrs. Eliassen's cow is evidently an illustration of this trend.

Recently, Bonnier[5] has attempted to deduce from sex distribution of twin pairs the frequency of monozygotic twinning and dizygotic twinning in cattle. Based on statistics of three Swedish breeds, Red-and-White, Friesian, and Polled Landrace, Bonnier estimates that about 8 per cent of the same-sex multiple births in cattle are identical twins.

About half of twin births in cattle, Bonnier finds, are same-sex pairs. Hence about 4 per cent of all twins are identical twins. This is much lower than the frequency of identical twins in same-sex births in humans which Bonnier computes by the same formula to be 39 per cent. On the basis of this estimate, identical twins would occur in Holsteins in $.015 \times .08$ births, which is twelve births in ten thousand.

The calves appear to be normal in every respect. They are in excellent condition and all seem likely to survive. They each weighed between forty and fifty pounds at birth. Growth since then has been normal, and at the present time it takes three cows to keep the quintuplets in milk. When they reach maturity, Mrs. Eliassen should have five excellent cows to add to her dairy herd. More important, she will have a unique troupe which should be a center of interest at state fairs and livestock exhibitions.

This will please Mrs. Eliassen if and when it comes to pass. Up to now, being hostess to this phenomenal visitation of the bovine stork has proved to be only a headache.—R. C.

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TWIN STUDIES ON AGING AND LONGEVITY*

FRANZ J. KALLMANN AND GERHARD SANDER

BECAUSE aging means "living" and attainment of old age denotes success in surviving a long time, the *biology of senescence* cannot be understood without reference to life itself in terms of the variable capacity for survival. From a biological standpoint, old age in man is a comparative classification of vitality relative to youthfulness, maturity, and death. It is as difficult to define, therefore, as is the quality of being human or the faculty of being alive in a human world.

Since intellectual maturation and sexual reproductivity seem to be the most specific points of reference, one may classify a person as "old" who is not young any more although he or she had been mature and potentially reproductive. One may also say that the person is old when still alive after having passed the psysiological age of creativeness and reproductivity. In any case, human life is as long and its senium as late as they are, because man must have an opportunity to contribute to the preservation of humanity before he can grow old and die, and because he must mature intellectually before he can be creative and before he should be procreative.

Psychologically it follows that satisfactory adjustment to aging can be attained only if the biological facts of life are clearly recognized, and their acceptance is woven into a plain design of living. In managing the psychiatric problems of the aged it seems even more essential than it is in any other attempt at correcting psychopathology of everyday life, that we learn to avoid "the frustration of misplacing our efforts and the embitterment of ill-founded hope" (Gregg).

The *social problems* created by the progressive trend toward higher ages are numerous, but still largely unsolved. With an increase in the average American life span from 49 to 66 years since the turn of the century, the proportion of persons living over 65 years of age has grown from four to seven per cent and is expected to reach fourteen per cent by 1980. At that time, almost half of our population will probably consist of persons who are over 45 years old.

Heredity and Longevity

Unfortunately, there is still a marked scarcity of pertinent genealogical information about the part played by *heredity* in the phenomena of aging and longevity in man. Much of this dearth is apparently explained by the multitude of technical difficulties encountered in geriatric studies. Since vital statistics became available only fairly recently, most of the earlier investigations such as those of Bell[1] and Beeton and Pearson,[2] were based on statistically inadequate sampling.[16] At the same time, there has been very little interest in an exploration of the genetic aspects of geriatrics with experimental animals.[4,6]

The most relevant genetic data on longevity were collected by Nollenburg,[11] the Metropolitan Life Insurance Company,[3] and especially by Pearl and his collaborators.[12] All of these studies showed a positive correlation between life spans of parents and their children, but they received only limited attention because of wide disagreement on their

*Second preliminary report on the progress of a study aided financially by The Rockefeller Foundation. From the Department of Medical Genetics of the New York State Psychiatric Institute, Columbia University, New York 32, New York, as presented at the Eighth International Genetical Congress in Stockholm, July 7-15, 1948, with the aid of travel grant provided by Mr. J. L. Lustberg of New York and by the Genetics Society of America.

genetic interpretations. Similar reservations are justified with respect to some rather dogmatic claims, made by Vogt and his co-workers[13] in a technically well-documented report on the hereditary causation of ,senile conditions of the eye "hitherto regarded as due to wear and tear or to external influences." Although the observations of the Swiss opthalmologists were accepted by Gruneberg[6] as "monumental" and as providing "about as much as twin studies will ever tell us," they were evidently obtained from a highly selected and numerically limited series of senescent twin pairs (58 sets over 55 years of age with only a few dizygotic pairs).

A State-Wide Survey

In the organization of our twin studies on the genetic aspects of aging and longevity (1945), the emphasis was placed on the collection of a statistically representative sample of aged twin pairs and their sibships (twin family method). For inescapable reasons of economy in refining the research procedure, the sampling of the index cases was restricted to twins who had passed middle age and resided in an area sufficiently accessible to the research staff. Acceptance of the first stipulation appeared advisable, since there was no reason to believe that twins have a shorter life span than the average single-born person, or geneticists a longer one. The second limitation was dictated by the need for continuous personal observation of all index cases throughout their period of senescence, and by that of arranging a truly cooperative and integrated system of mental health and social welfare agencies, local news services, and scores of public and private institutions for the aged. Another requirement was, of course, to include institutionalized senescent twins and recipients of old age assistance as well as self-supporting twins living outside of institutions, in order to avoid the most obvious factors of selection. Therefore, the sole criteria adopted for the sampling of our index cases consisted of multiple birth, survival up to the age of 60, and residence in the State of New York or in closely adjacent areas.

During the first three years of the survey, the carefully organized search for aged twins resulted in the collection of 1,602 index cases who formed a total of 933 index pairs (Table I). Most of these twins were still alive at the end of last year, including 431 pairs of whom both partners survived. At the time of the present analysis, the oldest living twin of the survey had reached an age of 102 years, while the oldest surviving pair was only 95 years old.

The pronounced excess of *female over male* index cases is in accordance with expectation. Differential mortality rates favor the female sex in most age groups, obtrusively reflecting either the consequence or the illusiveness of the popular notion that this is still a man's world. The sex ratio for our entire sample is 697 males to 905 females, and that for State residents outside of institutions is 464 males to 584 females. The corresponding ratio for the total State population over 65 years of age is 478 males to 570 females.

The proportion of *monozygotic* index pairs in our sample is about 30 per cent, also approximating very closely what may be expected theoretically in older age groups. The rate lies between that found by Weinberg for the proportion of monozygotic twins born in the United States between 1890 and 1900 (25.6 per cent) and the figure obtained by Yerushalmy and Sheerar[17] in a study of all twins born in the State of New York in

TABLE I. Current Distribution of Senescent Twin Index Cases According to Age, Sex, Zygosity and Survival

	All Twin Index Cases						All Twin Index Pairs			
	Current Status of Survival			Sex			Zygosity			
	Both Living	Both Deceased	One Twin Deceased	Male	Female	Total Number	Monozygotic	Dizygotic Same-Sexed	Opposite-Sexed or Unclassified	Total Number
60 – 69	492	59	224	340	435	775	125	156	202	483
70 – 79	262	71	210	258	285	543	78	85	142	305
80 and over	108	65	111	99	185	284	34	40	71	145
Total Number	862	195	545	697	905	1602	237	281	415	933

WHICH ARE THE TWINS?

Figure 2

The ladies in the picture are married to the gentlemen. In spite of the similarity in appearance, the men are brothers—not twins. They are also reciprocally brothers-in-law of their twin wives. The twins, who have the same birthday, though derived from separate eggs, appear to differ more in age than their husbands.

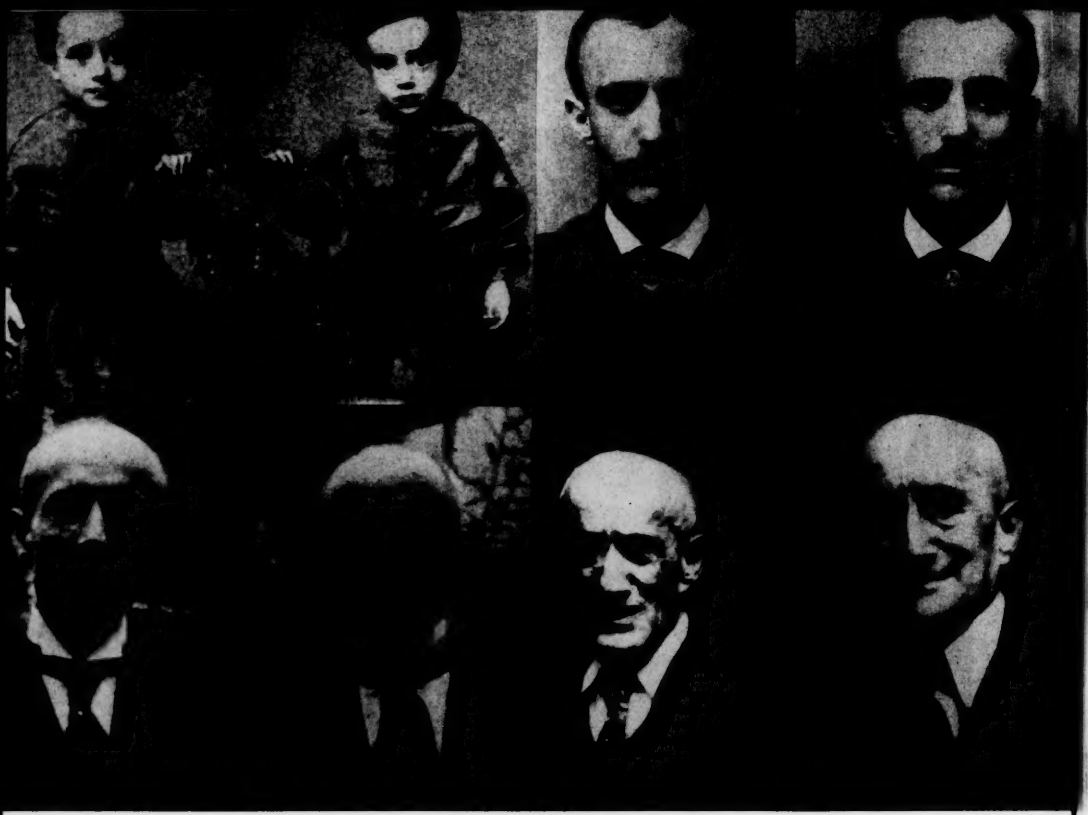
1936 and 1937 (32.6 per cent).

The preliminary comparison of intra-pair differences in *longevity* (Table II) cannot be expected to yield more than minimum differences between one-egg and two-egg pairs at this point, since the analysis is based on completed life histories; that is, only on the histories of those 58 pairs of our series, of whom both members died of natural causes in the age group over 60. If there is a genetic basis for longevity, the dizygotic group with still incomplete histories will include the largest proportions of index pairs in whom only one member has been capable of surviving.

TABLE II. Intra-Pair Differences in the Life Span of Deceased Twin Index Pairs

Age Group Referring	Average Intra-Pair Differences in Longevity, Expressed in Months of Life						
To First-Deceased Twin Partner	Monozygotic Pairs			Same-Sexed Dizygotic Pairs			Opposite Sexed Pairs
	Male	Female	Total	Male	Female	Total	
60 – 75	47.6	24.0	42.3	107.9	88.7	103.1	109.7
All Pairs Over 60	47.6	29.4	36.9	89.1	61.3	78.3	126.6

In view of this reservation it is rather striking that in comparing the life spans of same-sexed twins, the average intra-pair difference of monozygotic pairs is only about one-half that of dizygotic pairs. The difference between the two groups is approximately the same for the two sexes and is statistically significant at the five per cent level of confidence. The total mean difference is 36.9 months in the monozygotic group, 78.3 months in the same-sexed dizygotic group, and 126.6 months for all dizygotic pairs of opposite sex. If confirmed and possibly increased with the progress of the study, this differential trend would be conclusive evidence for the significance of genetic factors in longevity.



LIFE-LONG INDISTINGUISHABILITY OF ONE-EGG TWINS

Figure 3

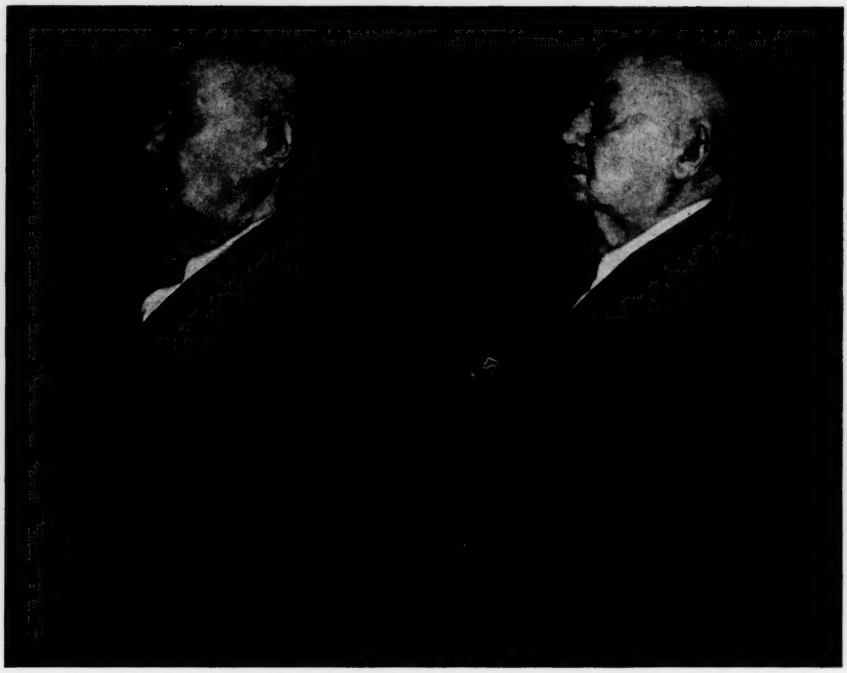
The N. twins looked alike at the age of four; and they continued to look alike at the other ages shown, namely, 25, 60, and 85. Since these twins differed considerably in their life histories the similarity in their aging can be attributed more to their identical heredity than to certain similarities in their environment.

A possible reflection of this trend may be seen in the finding that the dizygotic group contains no pair with a difference of less than three months between the deaths of the respective twin partners. However, among our monozygotic twins with completed histories there is one pair whose two members died the same day of similar natural causes at the age of 86. In addition, there were two monozygotic pairs whose members died only five and twenty-five days apart at the ages of 85 and 69, respectively.

The records of one of the latter pairs were notable for another reason. The twin sisters developed very similar senile psychoses at practically the same time, although there had been significant differences in their social and marital histories. One twin was married to a farmer and took care of a large family under typically rural conditions, while the other preferred to remain single and independent as a dressmaker in a big city. Nevertheless, their clinical histories paralleled each other to such an extent that both were reported to have become totally deaf and blind in the same month and to have sustained massive cerebral hemorrhages with similar hemiplegias on the same day.

Aging-Patterns

With regard to *physical manifestations of aging* it is hardly surprising that considerable differences in the visible expressions of senescence are found to be the rule in two-egg pairs, even in those with comparable environmental circumstances. The elderly twin sisters, shown



STILL ALIKE AT NINETY-FIVE

Figure 4

The oldest pair of twins currently included in the survey are the F. twins who are now 95 years old. Born in Poland, they have lived in this country for over sixty years. One of them speaks English fluently, the other not at all. But if they do not indulge in conversation, hardly anybody can tell them apart!

at age 65 in Figure 2, would probably have been unable at any age to attain a state of equally youthful appearance, even if they had employed the services of the same and most competent beautician. Actually, they resemble each other less with respect to apparent age than do the two gentlemen in the same picture, who are merely brothers, although they also happen to be husband and brother-in-law, respectively, by virtue of marriage to one of the twin sisters.

By comparison, the physical similarities of aging one-egg twins are usually much more pronounced. In fact, the permanence in the physical likenesses of monozygotic pairs may be so marked that some twin partners continue to be as indistinguishable in various stages of senescence as they had been in childhood or in their earlier years of maturity (Figure 3). The similarities often include the degree of general enfeeblement or its absence, the graying and thinning of the hair, the configuration of baldness and senile wrinkle formation, and the type and extent of eye, ear and tooth deficiencies.

In many one-egg pairs, the tendency of twins to remain physically alike throughout life is found to be expressed against the potential effect of modifying influences arising from entirely different environments. The differences in the life histories of a typical pair were those between a married country doctor

who had a large family and for over fifty years practiced medicine in the State of New York, and a Western rancher who never married but was successful in breeding stock. However, when the twins met after many decades of separation, they were found to have resisted the development of complete baldness with practically the same residual amount of hair.

That the physical likenesses of monozygotic twin partners may withstand both advancing age and environmental diversity is illustrated equally well by the F. twins (Figure 4) who, at the age of 95, are currently the oldest surviving pair of our survey. Their disparities of the past are collectively reflected in the interesting fact that one twin speaks English fluently, and the other not at all, though both have been in this country for over sixty years. In any case, by visual means it is still very difficult to tell them apart. Even their roentgenograms of the chest (Dr. L. Collins), the size and shape of their hearts, and the limb leads of their electrocardiograms (Dr. M. Harris) were found to resemble each other to a remarkable extent.

With respect to *mental changes* associated with aging, our preliminary psychometric analysis (Table III) was limited to the variance in intellectual performance as observed in a test series of 51 female twin pairs, living outside of institutions and considered testable on a long-range basis. The testing procedure was synthesized from various intelligence tests used for adults (Wechsler-Bellevue Test, Cornell Coxe Performance Ability Scale, Directions Test of Bronson Price and Merrill Revision of the Stanford-Binet Test). In collaboration with Miss Lissy Feingold, this psychometric program was organized in such a manner as to provide consecutive records of intra-pair differences in measurable intellectual deterioration.

According to the results of the first test round, the mean scores appear to be within the limits of normal expectation and are practically alike for monozygotic and dizygotic pairs. However, the mean intra-pair differences vary considerably from the one-egg to the two-egg group, notably in the first four of the six test methods used. With respect to the intellectual performances measured by the four tests, the intra-pair differences (between the two members of tested pairs) are definitely smaller for monozygotic than for dizygotic pairs. Since the given inter-group differences are statistically significant at the one per cent level of confidence, the obvious implication is that certain intellectual abilities depend on hereditary potentialities, which in their measurable effects remain variable from man to man until senescence.

The continuation of our psychometric analysis will make it possible to investigate variations in the tendency to senile deterioration in relation to both genetic and environmental influences. At this point, a thorough investigation of variable environmental factors is urgently required, especially in view of the anticipated suggestion that aged monozygotic twins should be more similar in intelligence and personality than an unselected control group of dizygotic twins, simply because they were apt to live and to age under more similar environmental conditions. The question arises, then, why it is that the environments of one-egg twins tend to be more alike than those of two-egg twins? And furthermore, is it for purely conventional or for more profound reasons that some of their similarities in social habits and basic personality traits have a tendency to persist until senescence even without similar environments? Since these similarities apparently extend to occupational and mate selection and possibly to

TABLE III. Intra-Pair Differences in the Test Scores of 51 Female Twin Pairs

Type of Test	Monozygotic Pairs		Dizygotic Pairs	
	Mean Difference	Standard Error	Mean Difference	Standard Error
Vocabulary	2.0	0.33	4.5	1.03
Kohs' Blocks	1.6	0.99	6.5	1.85
Memory for Digits	1.2	0.14	2.0	0.45
Digit Symbol Substitution	4.4	0.84	9.5	2.15
Similarities	2.5	0.49	3.8	0.82
Motor Coordination	12.4	1.02	14.5	2.64

certain aspects of survival and philoprogenitiveness, they will receive particular attention in our final analysis.

Marital Histories

Prior to such an inquiry it is advisable, however, to clarify a number of general biological problems in relation to the *marital* and *reproductive* histories of our twin pairs. The respective data are summarized in Table IV for all index pairs, in whom both members reached the age of 60.

With respect to the comparative rates of marital reproductiveness in same-sexed pairs, it is of special psychological interest that both sexes show significant inter-group differences in the proportion of celibate pairs (from 2.9 per cent for dizygotic male pairs to 20 per cent for monozygotic female pairs). It is also notable that it happened almost twice as often in monozygotic as in dizygotic male pairs that one partner had children, while the other did not (38.2 and 19.9 per cent, respectively). This difference is established for a five per cent level of confidence and seemingly supports the old superstition that one of identical twin brothers is doomed to be sterile, in analogy to the observation of freemartins in cattle.[10] We are inclined, however, to explain the discordant reproductivity rates of monozygotic male twins on a psychological rather than a biological basis. Marital disharmony seems to be particularly common in this category of twins, since their wives very frequently complain of having been unable to overcome the unusually close relationship between their respective husbands. Apparently, prolonged marital conflicts are not conducive to philoprogenitiveness.

Of more general importance is the finding of definite intra-pair differences in the number of children produced by married twin pairs concordant as to reproductiveness. The mean differences between monozygotic and dizygotic groups vary from 1.56 to 2.22 in the male pairs, and from 1.74 to 2.73 in the female pairs. This observation is not too difficult to explain with regard to female twin mates, in whom one might expect some influence of genetically controlled personality traits upon reproductivity. However, it certainly is surprising to discover indications of similar influences in the male sex. If confirmed, this finding would contradict the popular notion that the female partner is the chief determining factor in the regulation of family size.

Beyond question, the biological problems of human reproductiveness are as intricate as are those of aging and maturity. For many reasons, they still require more comprehensive investigations on larger samples of aged twin pairs with completed life histories. The same is true concerning the most essential element of old age, that of longevity. There is little doubt, however, that the genetic aspects of senescence can be explained only in relation to life and survival.

Using creativeness and reproductivity as the most specific biological points of reference for survival up to old age, it is justified to *conclude* from the available results of this study that *heredity and constitution play a basic role in determining the variable ability to maintain a relative state of physical and mental health until and through the period of senescence.* Within the genetically controlled limits of variability, human life can be lengthened or shortened by outside factors and the degree of efficiency in utilizing constitutional potentialities, but in terms of present knowledge it cannot be prolonged beyond the present boundaries of man's vital capacity.

TABLE IV. Marital Status and Reproductiveness of 340 Same-Sexed Index Pairs

	Marital Status in Per Cent			Reproductiveness in Per Cent of Married Pairs			Average Marital Reproductivity	
	Both Single	One Married	Both Married	Both Childless	One Procreative	Both Procreative	Fertility Rate	Intra Pair Difference
Monozygotic Pairs:								
Male	11.3	11.3	77.4	3.6	38.2	58.2	3.25	1.56
Female	20.0	16.7	63.3	7.0	22.8	70.2	3.68	1.74
Dizygotic Pairs:								
Male	2.9	17.1	80.0	14.6	19.9	65.5	3.67	2.22
Female	11.0	16.5	72.5	5.1	31.6	63.3	3.93	2.73

In reflecting upon possible genetic methods of *extending* the limits of the current human life span, it seems logical to expect that future generations would tend to respond to a general extension of their intellectual and sexual maturation periods with a gradual increase in longevity. Unfortunately, so little information is as yet available on the biological relationships between age at pubescence and significant variations in the length of life, that any practical use of this reflection may have to be postponed until the next millenium.

Summary

1) The practical problems of senescence and longevity have been multiplied by the progressive increase in man's average life span. By 1980, it is expected that one-half of our population will consist of persons over 45 years of age.

2) In order to study the interaction of genetic and environmental factors in relation to aging under experiment-like, but mankind-specific conditions, the long-range observation of a statistically representative sample of aged twin pairs and their sibships is the method of choice (twin family method).

3) During the first three years of this study, a total of 1,602 twin index cases over 60 years of age was collected from both the general and hospitalized populations of the State of New York. At the end of 1947, one or both twin partners were still alive in 92 per cent of the index pairs.

4) The adequacy of the sampling of the 933 index pairs included in this preliminary analysis is indicated by the sex ratio of 697 male to 905 female twin index cases and by the ratio of 237 monozygotic to 548 dizygotic index pairs.

5) Many physical and psychological similarities of monozygotic twin partners have been found to have a tendency to persist throughout life. Their likenesses definitely exceed those observed in dizygotic pairs and frequently withstand advancing age as well as significant environmental diversity. The personality features, which have been shown psychometrically to depend on genetically produced potentialities, include various intellectual abilities.

6) Monozygotic twin partners of either sex differ less in their rates of marital reproductivity than do same-sexed dizygotic partners. This finding disagrees with the popular notion that the female marriage partner is the chief determining factor in the regulation of family size.

7) In a comparison of the life spans of same-sexed twin partners, the significance of genetic factors in longevity has been demonstrated by the finding that the average intra-pair difference of monozygotic pairs (36.9 months) is only about one-half that of dizygotic pairs (78.3 months). This inter-group difference is expected to increase with the progress of the study.

8) From a biological standpoint, the concept of senium denotes survival beyond the physiological age of creativeness and reproductivity.

9) Within the genetically controlled limits of variability, human life can be lengthened or shortened by outside factors and the degree of efficiency in utilizing constitutional potentialities, but it cannot be prolonged beyond the present boundaries of man's vital capacity.

10) In a human world, old age is a comparative classification of vital efficiency and as relative in its meanings and connotations as is the faculty of being alive or the quality of being human.

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RADIATION DAMAGE OF GENETIC ORIGIN

Abstract of National Sigma Xi Lecture by Dr. H. J. Muller

THE great majority of gene mutations are harmful in some way, but they are seldom obvious. They accumulate in populations, over the course of generations, according to definite laws. As a result, practically all individuals in a population are suffering to some extent from inherited mutations which arose in their distant ancestors. In addition, each individual carries, in hidden form, far more mutations than those which he himself directly suffers from, but these will eventually show in some of his descendants.

It is evident that any agent or condition which affects the rate with which these hereditary ailments originate in a population is of prime importance, since the frequency with which mutations "show" is, in the end, directly proportional to that with which they originate. Among agents of external origin to which people's reproductive organs are likely to be subjected, high energy radiations, capable of causing ionization, is the only agent so far found to affect the mutation frequency to a very marked degree. The gene mutations thereby induced are similar to those occurring naturally, and are to a similar extent harmful. Their frequency is directly proportional to the total dose received, no matter whether the treatment is concentrated, fractionated, or prolonged. There is no dose too small to have some effectiveness, and there is no recovery from the mutational effect, even though the reproductive organs may retain, or regain, apparently normal functioning.

It can be reckoned that the skin dose commonly received in a single fluoroscopic examination ("screening") of the abdomen, for diagnostic purposes, would, if received by the *gonads*, produce about as many mutations as occur naturally during an individual's reproductive life-cycle. Thus if each individual's gonads on the average, received a total of only this much X or gamma ray exposure, between the time at which he was conceived and that at which he reproduced, and if this practice were to be continued in each generation, indefinitely, the population would eventually come to suffer from twice as many hereditary ills as it does today. Another way of putting this is to say that each such dose probably carries something like a 5% chance of handicapping several descendants and of finally killing one of them in some future generation.

In the case of most mutations, however, there is a lapse of many generations between the moment at which the mutation originated and that at which it produces its effect upon an individual. This is because of most mutations being recessive, i.e., not "showing" until two germ cells both of which happen to carry the same mutant gene met in fertilization. This time lag is of the order of thousands of years. Hence the exposure of individuals of any one generation even to the maximum dose they can tolerate is not likely to be followed by a detectable increase in the number of mutations appearing in the next or in any one successive generation, even though very many mutations have in fact been produced and though these will "show" eventually. For this reason we need not expect even the survivors of atomic bombing to produce children demonstrably less normal than those of unexposed persons. The mutations are like minute time bombs that are saving up their charges for the distant future. This is likely to make us much more reckless of these effects than if they were exerted mainly in our own or our children's generations.

The same kinds of gene mutations as are produced in the germ cells have been shown to be produced likewise in the other cells of the body, the somatic cells. But again, because of being recessive, they can seldom produce noticeable effects, and then only if the individual cell in which the mutation occurred was one which was in a position to multiply, so as to form a whole group of aberrant cells,

or patch of tissue. If, however, the mutation were such as to give the cell a tendency to unregulated multiplication a condition would arise like that found in malignant tumors and leukemias. This makes understandable the finding that ionizing radiation does result in a heightened frequency of such conditions, and that the conditions often become evident only many years afterwards, presumably when the mutated cells are given a chance to multiply.

Besides inducing gene mutations, such radiation produces another type of genetic change: breakage of the chromosomes. This probably occurs with a frequency somewhat higher than that of the gene mutations, but again proportional to the total dose received. The broken ends of the chromosomes are adhesive to one another. As a result the two fragments may reunite so as to restitute the original chromosome in undamaged condition. The parts may, however, unite in various other ways, so as to give recombination-chromosomes of different kinds, known as "isochromatids," "translocations," "deletions," "inversions," etc.

Some of these arrangements are seen to result from a single chromosome break, and the frequency of these is therefore directly proportional to the total dose of radiation. Others require two or more breaks, the fragments from which unite with one another. Their frequency has an exponential dependence on the dose given within such a time as to allow the fragments to be available for uniting with one another. Since, however, the dense ionization paths resulting from fast neutrons and from protons and alpha rays commonly produce more than one break at a time (when they produce any at all), the multibreak rearrangements show essentially a linear relation to the dose when such radiation is used. At low dose, therefore, neutrons, protons and alpha particles are far more effective than X or gamma rays in causing these changes.

It is shown that changes of the above kinds result in viable or inviable chromosomes according to the accident of whether the recombination-chromosomes are provided with one and just one 'centromere" (point of attachment of tractive fiber), to insure their being pulled into the daughter cells at the time of cell division. If viable recombination-chromosomes are produced in germ cells, these chromosomes can be studied by genetic and cytological means. In nearly all cases there is demonstrable damage, usually leading to death *in utero*, in the second and following generations after treatment. When non-viable chromosomes are formed in germ cells that undergo fertilization, there is death *in utero* in the first generation after treatment.

These same changes which have been found by the genetic tests to occur in the germ cells are likewise induced in the other body cells, those of the somatic tissues. The formation of inviable chromosomes leads to the formation of abnormal and moribund daughter cells, when division of the exposed cells occurs. There are several reasons why the effects are produced preferentially in tissues in which cell division occurs oftener. This gives an interpretation of the long known "Law of Lacassagne," according to which faster-growing, proliferating tissues are on the whole more detrimentally affected by radition than those which undergo growth and cell division more slowly or not at all. Applications of this principle are cited.

Most of the long-term damage caused to the body by radiation, apart from malignant growths, can be interpreted as resulting from the above effects on the chromosomes of dividing somatic cells. It is to be expected that such damage would be insidious but far-reaching, and that some of it would be produced even by very low level exposures if these were long continued. That this is in fact the case is indicated by the recent findings of Boche on the significant lowering of the life span by such treatment, as well as by other data.

The above considerations show that the indications hitherto commonly used by those dealing with ionizing radiation or radioactive materials as guides for keeping within "safe" dosage limits—namely, the avoidance of reddening of the skin, falling out of hair, change in the blood count, loss of sperm motility, etc.—are by no means reliable criteria, and that important damage to the individual himself can result from a repetition of doses far too small to give these more obvious effects. It is in a sense providential that this damage to the individual should result. For it is probable that far greater damage is, in the end, caused to future generations by the same dosage. Human foresight and social consciousness have not yet reached the point, however, where many persons, even if medical men, would let the five per cent chance of crippling of some far future individuals bother them in deciding to use a procedure which has a good chance of being of even a little help to someone here now, despite the existence, in many cases, of alternative procedures. But when it is realized that the individual himself runs some risk, the interests of future generations will automatically be better protected.

SPILLMAN AND GENETICS

THE independent and virtually simultaneous discovery of some of the mendelian generalizations by de Vries, Correns and von Tschermack at the turn of the century was so dramatic that it is frequently mentioned in the literature of genetics history. The parallel work of W. J. Spillman in Washington with its important outcomes is so rarely mentioned that it was a real pleasure to find the articles by L. P. V. Johnson and Dr. Ramsay Spillman in the September number of THE JOURNAL OF HEREDITY.

The only explicit linking (that I have seen), of Dr. Spillman's work with the now classical trio occurs in J. Allen Clark's chapter, "Improvement in Wheat," in the 1936 Yearbook of the U. S. Department of Agriculture, p. 323, to which Dr. Johnson refers. In the 1937 Yearbook's chapter, "A Chronology of Genetics" by Robert C. Cook, occurs the statement, "Spillman's wheat work in the United States had reached a point where he appears to have been just on the brink of making the same illuminating generalizations." (p. 1464) We would probably all agree with Dr. Herman J. Muller's sentiment (in his letter to Dr. Ramsay Spillman in the same number of THE JOURNAL OF HEREDITY) that Spillman's discovery "should be more recognized in the history of genetics—especially of American science." Certainly it is a matter of common decency to give credit for contributions from whatever source; and certainly scientists are not, as a group, disposed to quarrel about priorities for credit (although there are of course exceptions). My own interest is not so much a concern for alloting credit to the various individuals who have contributed to the growth of science as concern for the students and readers, who are entitled to a better perspective on the social sources and the social implications of "science". And my own interest is not so much in the history of genetics as in the social processes by which ideas emerge in scattered regions and eventually fuse into powerful forces that modify cultures and eventually overthrow them.

I have brought Spillman's work into the story in my first biology textbook and in my last. *Elementary Biology,* published in 1919, described the work of Dr. Spillman briefly as an example of the scientific attack on a definite technical problem, in rather local and special terms (soil, climate), and showing the relation of the work to Mendel's procedures and findings (p. 450). In my *Biology and Man,* 1944 (with N. E. Bingham), there are more details on the parallel between Spillman's work and that of Mendel and of the "rediscoverers" of the mendelian principles (pp. 479-481).

It is very fascinating — but futile, probably — to speculate on what might have happened *if* something in the past had turned out differently. *If* Mendel's original paper had been published in some widely read Berichte or read before an important royal academy, hundreds of men who have since become famous would undoubtedly have found roads to distinction other than the ones they did respectively follow. Possibly the science of genetics and the art of creating plants and animals to meet specifications would have been advanced more rapidly. As it is, Dr. Spillman, with a practical breeding problem before him, did consider each of several significant characteristics of his problem-plant *separately,* as did Mendel; he recorded and *counted* the occurrence of each character in every plant, as did Mendel. Neither Dr. Johnson nor anybody else need regret or apologize regarding the fact that "Spillman did not take the next step as did Mendel." The implied wish seems to be a vestige of a certain invidious distinction between "pure" science and other kinds.

Would Spillman have taken that "next step" *if* he had not learned at the 1901 meeting about Mendel, deVries and

the others? Probably not, although it is futile to speculate. Dr. Spillman's son writes, "The acclaim which greeted my father's presentation in 1901 was the direct instrument of taking him out of the active field of genetics." (p. 253, JOURNAL OF HEREDITY article.) Just so. Dr. Spillman did not stop in his tracks on hearing about Mendel. He took a considerable number of next steps, continuing what he had started out to do, namely, improving wheat varieties. It would be just as fascinating (and probably just as futile) to speculate on what would have come of Mendel's experiments *if*, instead of selecting the seven characteristics of his garden peas that he did work with, he had selected a different combination of characteristics. I understand that these seven are virtually "independent" genetically; and that was very fortunate for all of us.

The history of science is full of independent and *almost simultaneous* discoveries — creative inventions of dynamic concepts. The Wallace and Darwin case is perhaps most familiar to biologists; but there are many others in every branch. Such "coincidences" are more than historical curiosities. Our science teaching is impoverished by the almost universal disregard of the historical and social settings in which great investigations and important discoveries were made. I am impressed by the general impoverishment of much of our teaching where personalities or localities are involved. Nationalistic (and even chauvinistic) bias restricts the effectiveness of the teaching and eventually the understanding of the learners.

By all means, let us include the "contributions" of Americans and Czecks and Dutchmen and Hindus; but also the contributions of empiricists and clinicians and engineers and practical agriculturists. The first is necessary to help students to appreciate the comprehensiveness of science as a mode of human behavior, as a method of approaching problems that is in harmony with human nature everywhere. That is, science is not peculiar to "western" civilization or the superior races or the privileged classes. Science is indeed the one creation of mankind that can today claim to be equally accessible and equally productive everywhere and for everybody: its effectiveness does not depend upon religious or political preconceptions of the people who wish to cultivate it or to use it.

The second is equally necessary to help students to appreciate the relationship of science to mankind's practical work—in which science is rooted and from which it derives its ultimate sanctions, namely, the *workability* of its concepts.

BENJAMIN C. GRUENBERG

Neither by Magic Nor by Gadgets

IN discussing the role of Mendel and of Spillman in the development of genetic concepts, it seems to this writer that Dr. Gruenberg misses an important point. This has to do with the stroke of genius that Mendel displayed *after* he had recorded and counted each different kind of plant in the segregating generations; and *after* he considered the combinations of these characters in the progeny. Mendel went on to the *why*, and it is precisely at this point that he displayed pure genius. Why were there in the second hybrid generation three plants (on the average) resembling the dominant parent, and one plant (on the average) resembling the recessive parent of the original cross? Mendel conceived that this result would be obtained if the following conditions were satisfied: that the hereditary precursors in the gamete were: (1) equally numerous; (2) "pure"; and (3) that separation of these two kinds of gametes in pollen and egg, and their recombination at fertilization, were at random.

That this "next step" was taken by Mendel and not by Spillman seems to this writer to have nothing whatsoever to do with "pure science" versus "applied science." Very likely it was only a question of time. Mendel had striven with his problem a number of years. In only two years Spillman had his problem organized, and was on the right track. In a few more years his kind of mind very likely would have arrived at the *how* and the *why* of "every possible combination of the original parent

characters" and of the "hybrids between them."

Mendel's paper presents in perhaps unique simplicity and lucidity a picture of the human mind dealing with data as an abstraction, and creating an hypothesis to account for what has been observed. The great lesson to be learned from Mendel's report is the clear understanding it gives us of the basic method of science. We take what is given, the data; we create an hypothesis to account for what is given. If our hypothesis is sound the results are accounted for, and new data strengthen our confidence in the validity of our hypothetical explanation. The factors in the gametes Mendel postulated as pure concept: pure scientific abstracts. Their physical existence was not to be revealed until the union of cytology and genetics 35 years later. But the assumption that the separation of his hypothetical factors was at random; that they were equally numerous, and that combination of them to form zygotes was not selective gave us the first biological science with a clearly defined mathematical basis. And it cleared the way for the fruitful experimental study of a subject which prior to that had for centuries been imprisoned in a dead end of purely deductive philosophy.

It is also interesting to recall how in the case of Mendel's discovery his hypothesis stood up even when wider knowledge and new data forced a modification of some elements of the original interpretation. Such modifications do not necessarily invalidate the original concept, as we would be led to believe by the literary idea of the "crucial experiment." Thus linkage modified the concept of independent assortment and epistasy changed the "classical" Mendelian ratios. But for all that the basic principles required no modification. Actually "the exceptions" which Bateson advised us to treasure have strengthened them. If the "rule" is accurately congruent with reality it grows on exceptions.

This brings us to the question of the "independence" of the seven different factor pairs Mendel experimented with. Mendel was fortunate in his choice of the pairs. Such luck, as Morgan pointed out in his Presidential address to the 1932 Genetics Congress, must often be depended on to feed scientific advances. Whether Mendel encountered complications in other material he may have worked with is a possibility. The first instance of genetic linkage, called "coupling and repulsion" by its discoverers, Bateson and Punnett, was observed in the sweet pea. And it is of interest that to account for this phenomenon Bateson and Punnett elaborated the hypothesis of differential fertilization or "anisogeny" as they called it. This held that fertilization was selective—not at random—in some instances, and had the principle of anisogeny been established, genetics might have been far less dominated by the mathematics of probability than is the case today. But linkage, not selective fertilization, proved to be the true explanation for the aberrant ratios obtained in the F_2 segregation of pollen-grain shape and flower color in the sweet pea.

It is noteworthy that Mendel's basic law with respect to the segregation of single factor pairs still held in linked material. Even had he become involved in the complication of linkage, his bright and dull plants, and his tendril and acacia plants would still have segregated in the expected ratio. Thus the complication introduced by linked material would have invalidated only the principle of independent assortment.

The luck that protected Mendel from such complications as linkage and genic interaction more than once has played a critical part in genetic science. Consider the fortunate choice by Morgan of the vinegar fly as material for the development of his "theory of the gene." Before anybody had examined the chromosomes of this useful creature, Morgan had begun his work. It was pure chance that *Drosophila melanogaster* had only four pairs of chromosomes. Furthermore, nobody "planned it" that these chromosomes would be found in the tissues of the salivary glands expanded into relatively huge structures that are visible with a hand lens.

Some investigators were not so fortunate. Woodworth in the early days undertook to use another simple organism, *Paramecium*, for genetic experimentation. Unfortunately the "simplicity" of *Paramecium* turned out to be mostly illusionary. Tucked away in this tiny protozoan is a nucleus with a hair ball of chromosomes not even yet accurately counted. Furthermore the peculiar mating habits displayed by this creature allow us to state, loosely and inaccurately, perhaps, that there are a number of different "sexes" in this organism instead of merely two. Because of these and other complications it took almost a quarter of a century to figure out the basic biology of *Paramecium*. When this was done, Jennings and Sonneborn and others found this creature a very valuable organism for genetic research. Similarly, ill luck dogged de Vries in picking the evening primrose for his experiments. Not until Belling's segmental interchange principle had been accepted was it possible to explain the peculiar genetic behavior of this assumably "simple" plant.

Exactly where Mendel's discoveries would have been re-made *in toto* by another is a matter for argument. By the turn of the century, when de Vries, Correns, and von Tschermak rediscovered Mendel's laws, the exploration of the physiology of the nucleus was just getting under way. The process of meiosis was then first subjected to intensive scrutiny. It would appear almost inevitable that quite soon after the reduction of the chromosomes at meiosis had been established, this phenomenon would have been related to observations such as Spillman's regarding character combina-

tions in hybrids. Hence it would be an exaggeration to allege that had Mendel's amazing insight never been given to the world, genetics would have forever languished. But this is not quite the same thing as the doctrine of the "inevitability" of discoveries, which is the basic tenet of the proponents of the "social wave" concept of scientific progress.

That these fascinating coincidences, "perhapses" and "might have beens" of science have definite value as teaching material there can be little doubt. We tend too much to make science a cold abstraction, rather than the exciting flux of strivings, disappointments, and, occasionally, of epochal achievement, that it is.

Another point of some importanec in the history of science deserves comment. It has been assumed by several writers and is again stated by Dr. Gruenberg that Mendel's work was eclipsed merely because it was published in an obscure journal. This is not quite true. The proceedings of the Brünn Natural History Society were rather widely distributed. Copies of Mendel's original paper were to be found in most of the important biological libraries and in the larger general libraries of the world. Furthermore, Mendel took the trouble to send reprints of his article to several distinguished botanists, probably to many. The only thing that ever came out of his attempt to call attention to his work seems to have been Nägeli's pedantic brushoff, suggesting that the good Abbot go back to some really useful branch of botanical activity. The truth is that at the time Mendel announced his discovery nobody in the field of biology had traveled far enough along the line of thought that Mendel was pursuing to be able to evaluate his work intelligently.

As has been shown to be true in the history of science so many times, *we only see what we are looking for!* That kind of blindness applies both to pure science and to applied science! Among scientists generally an ardent conviction exists that bad as the myopia of the pure scientist may be with respect to new and illuminating generalizations and to fruitful hypotheses, it is much worse among applied scientists. When we attempt to put our questions to Nature purely in utilitarian terms the breadth of field and the depth of focus of those who do the questioning tend to contract as the scientific drive gives place to the gadgeteers' urge for "practicality." Old Dame Nature is definitely an elusive and perverse creature and she has her own ways to even the score with those who attempt to give her a dialectical bum's rush. How silly she manages to make the advocates of such methods look, Comrade-Academician Trofim Lysenko is blythly on his way to finding out.

For these reasons, among others, scientists generally look with a very jaundiced eye on ambitious programs for "planned research," where you put your money in the executive slot—Governmental or Foundational—and out pops your lollypop of "results."—R. C.

✦

Dr. Spillman's Own Statement

RELATIVE to Dr. Spillman's discoveries in genetics, Johnson* states (p. 247): "the question arises as to whether Mendel's work was known to" Spillman before he presented his own data. He adds (p. 247) "The assumption seems fully justified that Mendel's discovery was at that time unknown to Spillman." In his note on the same subject, Dr. Ramsay Spillman states† that this presumption is correct.

Spillman himself verified the correctness of this situation first implicitly, and then explicitly. The implicit verification‡ occurs in the statement: "Mendel's law as first stated independently in this country (*Bul. 115* Off. Ex. Sta., p. 93) and essentially as stated by himself, . . ." The explicit statement occurs in a slightly later paper§ as follows: "At the time that paper was prepared the writer was not aware that others had published anything on the same subject. We now know that Mendel, DeVries, Correns, and Bateson have . . ."

These two statements leave no further question as to the independence of Spillman's conclusions. Whether those conclusions constituted an independent discovery of Mendel's laws is another question. To me, the last two paragraphs of Johnson's paper phrase this question well and adequately.

FREDERICK D. RICHEY
Knoxville, Tennessee

*Johnson, L. P. V. *Jour. Hered.* 39:247-252. 1948.
†Spillman, Ramsay. *Jour. Hered.* 39:253-254. 1948.
‡Spillman, W. J. *Science* 16:709-710. October 31, 1902.
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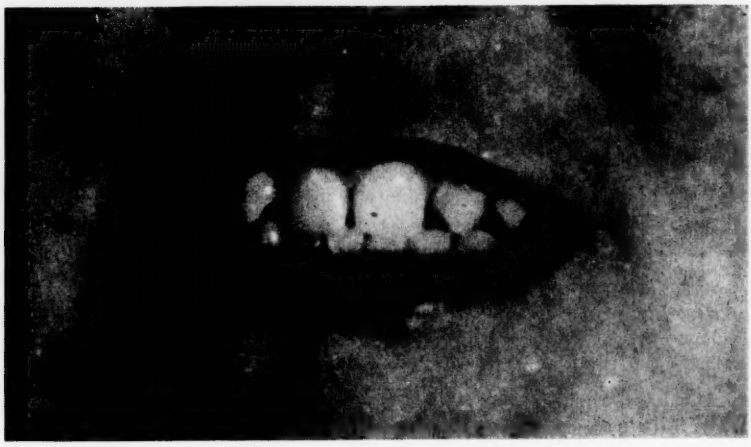
INHERITANCE OF MISSING INCISORS

HUGO ILTIS
Mendel Museum, Fredericksburg, Va.



TWO INCISORS INSTEAD OF FOUR—CASE I

Figure 5

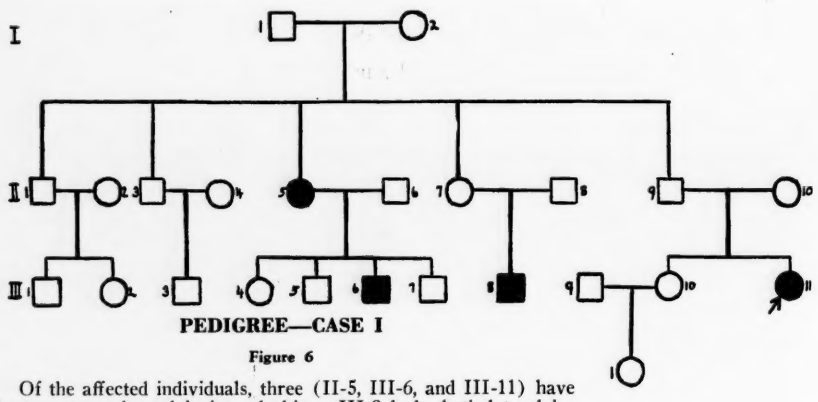
Proband of the first case (Pedigree in Figure 6). Note the large upper incisors as compared with the four small incisors in the lower jaw. The upper lateral incisors are missing.

THE absence of one or both upper lateral incisors is, like the absence of the third molars (wisdom teeth), one of the most common of human hereditary variations. Röse,[7] in an extensive study, found degeneration or absence of the upper lateral incisors in Scandinavia in six per cent of the population; in Central Europe in between two to four per cent, among colored races in about one per cent. Hrdlička[4] found degeneration of the upper lateral incisors in three per cent of a thousand white Americans. Like Röse he found absence of one or both upper lateral incisors more frequent in females (3%) than in males (1.4%). In a more recent investigation, Campbell[1] reports that in 3,550 patients 3.7 per cent lacked both upper lateral incisors. This probably gives a reasonable basis for estimating the gene frequency.

Absence of upper lateral incisors is not restricted to modern man but was found, though less frequently, in fossil human skulls (0.1% by Schultz[8]) and in the skulls of monkeys.

In spite of the frequency of the variation, the publication of our two cases may be worth while, since their mode of inheritance differs clearly from those reported by other authors and since this difference may illuminate the problem of the inheritance of human characters.

The reduction of the number of teeth may be called a "meristic variation" according to Bateson's terminology. Many authors write of "the tendency to reduction" of the human dentition which is considered by Schultz[8] a "regressive variation" connected, perhaps, with the "change of food habits" (Sergi[10]). Formulated in modern concepts that would mean that the mutation, which probably depends upon a gene inhibiting the development of the upper lateral incisors, is not eliminated by natural selection since its adverse influence is balanced by the



PEDIGREE—CASE I

Figure 6

Of the affected individuals, three (II-5, III-6, and III-11) have the two upper lateral incisors lacking. III-8 lacks both lateral incisors in both jaws. The defect seems to be conditioned by a recessive gene.

change of food habits. Similar genes are connected with the inhibition of the development of the lower medial incisors and of the third molars (wisdom teeth). These three centers of reduction concern those teeth which are less essential, due to the adoption of softer foods.

A characteristic correlative development which has been observed by several authors, and which characterizes also both cases reported here, is the compensatory increase in the size of the remaining upper medial incisors.

The two pedigrees described below concern the ancestry of two students at Mary Washington College. To both the students and their families I give my thanks for their friendly cooperation.

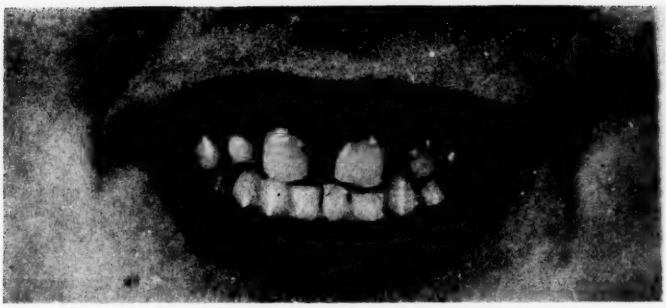
The proband of the first case, of perfectly normal and healthy appearance, showed superficially a dentition which seemed completely normal. There was not even a frenum present between the medial incisors, as is usually the case when the laterals are missing. As compared with the four lower incisors the two upper ones were considerably increased in size. Immediately adjoining them are the canines. The lateral incisors are completely absent. The x-ray photo shows that there are no buds of incisors retained in the jaw. Both third molars are present. This case is different from most similar ones since the wisdom teeth usually are also absent when the upper lateral incisors are missing.

The pedigree (Figure 6) shows four cases in two generations. The proband believes that the condition also was present in the preceding generations, but no reliable records were available. Of the four cases, two were males and two were females. In two cases neither of the parents showed the character, but it appeared in their child. This is especially conspicuous in III-8, who lacked both upper laterals and both lower medial incisors, while the dentition of his parents was normal. The pedigree suggests a recessive gene for the tooth defect.

NO LATENT INCISOR BUDS—CASE I

Figure 7

X-Ray photo of the upper jaw of Proband I (Figure 5). There are no buds of the missing incisors retained in the jaw.



LACK OF INCISORS—CASE II

Figure 8

Proband of the second case showing spacing different from that in Case I. Note the frenum between the two large upper incisors.

The second case was more complicated. Again the proband, age 17, was of perfect mental and physical health. The two medial upper incisors showed the characteristic increase in size. Between them is a well developed frenum. There is also a free space between the upper left incisor and the cuspid. X-ray examination, kindly performed by Dr. C. P. Kennedy, showed no incisor buds retained in the jaw. The cuspid on the right side was a baby tooth while the permanent cuspid was still retained within the jaw bone. Neither wisdom teeth nor incisor buds were present in the upper jaw.

The pedigree (Figure 9) shows nine cases in two generations. The character was probably present in the preceding generation, but no reliable records were available. It appears that the gene was transmitted into the family by the two sisters I-2 and I-3, whose children the first cousins II-3 and II-4 married. Five cases of missing incisors are reported in the succeeding generations.

In this pedigree there are three instances where neither of the parents of an affected individual showed the deficiency. This pedigree also favors the conclusion that the gene in question is probably recessive. This assumption is also supported by the fact that none of the four children of the affected mother (III-5) manifested the defect.

The preponderance of females in this pedigree agrees with the reports of other authors.[4]. There is, however, no reason to consider the character sex-linked.

It is perhaps worth noting that a particular syndrome (no lateral incisor on one side—baby tooth incisor on the other side) is transmitted from the mother (III-9) to her son (IV-9).

Inheritance

Many other cases of missing incisors have been described in the literature, but in none has a recessive mode of inheritance been reported. Jöhr[5] made an extensive study of an isolated Swiss village noted for the high frequency of missing incisors. Of 162 persons investigated about one third showed reduction or absence of the upper lateral incisor. An extensive pedigree confirmed the "dominant inheritance of this condition."—Wheeler[12] calls the character dominant; Keeler and Short[6] "an irregular dominant"; Schultz[9] "an extreme case of a dominant character which is more frequent in the female." Hoskins describes the gene in the families he studied as a "sex-linked partial dominant" and explains the abnormal inheritance by the "variability in penetrance and expressiveness of a sex-linked gene."

Our recessive case completes the entire scale of inheritance from "dominant," to "irregular dominant," to "sex-linked" and "recessive." A similar situation is also found in many other hu-

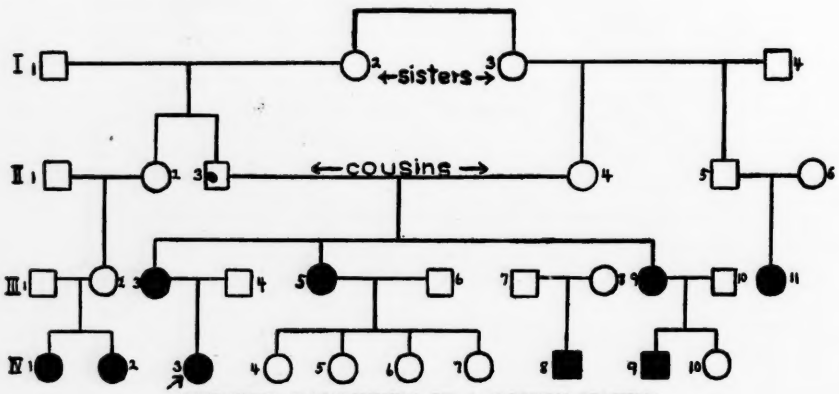


Figure 9

III-3 lacked wisdom teeth, and showed no unerupted buds. Five affected individuals in the pedigree (III-5, III-11, IV-2, IV-3, and V-8) have no lateral incisors. III-9 and her son IV-9 had no lateral incisors on one side, but had retained baby-tooth incisors on the other side. The proband (IV-3) has a baby canine tooth retained on one side. IV-1 died toothless at three.

man characteristics and abnormalities. Gates[3] mentions that, for instance, Leber's optic atrophy and nystagmus occurs in that "triat of dominant, recessive and recessive sex-linked forms" and so does retinitis pigmentosa. Gates quotes a pedigree of nystagmus reported by Hemmes where the descendents of one brother show dominant inheritance, the offspring of the other one transmission by a sex-linked gene (!). The explanation of these and of similar instances by a "sliding scale of values" (Gates p. 425) or by a "change in penetrance and expressiveness" (Gates p. 15) is but a polite paraphrase of our inability as yet to explain inheritance in these cases by Mendelian segregation. For we must not deceive ourselves—a "labile gene" (Ernst[2]) is not a Mendelian gene, the very basis of which is constancy.

Studying such encyclopedias of human genetics as those of Gates or Baur-Fischer-Lenz, we shall not find too many instances of clear-cut Mendelian segregation of human characteristics. Even in those characteristics which are usually cited in textbooks as notable examples of a specific type of segregation (brachydactyly or diabetes insipidus for dominant, albinism or feeblemindedness for recessive, color-blindness or hemophilia for sex-linked inheritance) are not always "classical" in their inheritance.

Part of our difficulties are due to the fact that "man is not a satisfactory experimental animal."[11] Hence we must confess today, after almost half a century of research that our knowledge regarding the inheritance of human characteristics is still inadequate. We need more knowledge, and we have every reason to be modest in our conclusions and very careful in formulating practical applications.

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DUN COAT COLOR IN HORSES

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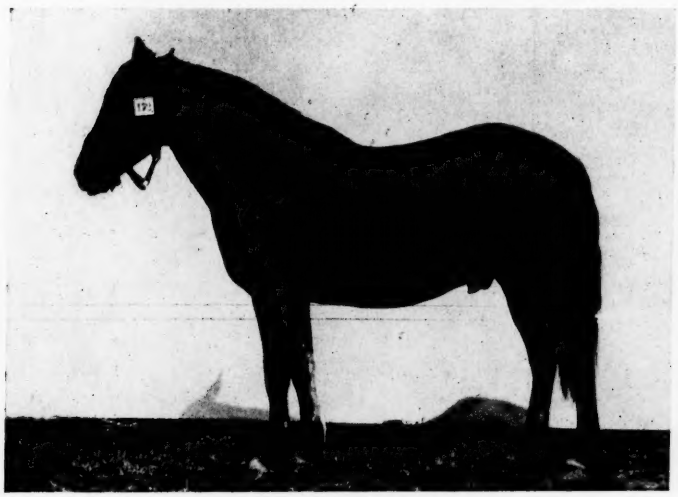
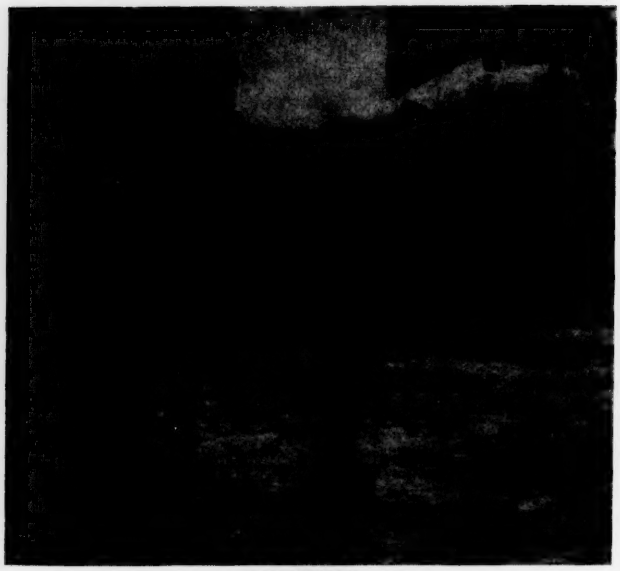


DUN PATTERN
Figure 10
The mane and tail black in contrast to the Isabella-Palomino.

IMPORTANT contributions to our knowledge of the inheritance of coat color in the horse have recently been made by Salisbury and Britton[1] and by Castle.[2] These investigators confirm the earlier views of Wilson[3], Wriedt[4] and others that the colors dun and cream were due to a dominant dilution gene in a heterozygous condition acting on certain basic colors, and they go on to show that the Palomino is a special case of this. Castle also considers the possibility of determining whether or not dominant white in horses is allelomorphic to this dilution gene producing dun.

These recent writers make no mention of Walther[5] who concluded on the basis of his investigations that gray, bay, black and red formed an epistatic series, and that if a gene for yellow were combined with black and bay a dun would result. Neglecting grey, a horse carrying neither black nor bay would be red (chestnut) unless it also carried the gene for yellow in which case it would be Isabella (Palmoino?). Walther conceives that yellow can be homozygous; so according to him two homozygous Isabellas mated together could produce only Isabella progeny, and heterozygotes would produce chestnut and Isabella progeny in the ratio of 1:3. In view of recent evidence we may set aside the possibility of homozygous Isabellas, but Walther goes on to claim that the presence of the gene for yellow does not affect in any way the appearance of black if bay is absent, although it dilutes red if both are absent. This is contrary to the view of Soplakow and Wasina[9] who take the view, as we do, that the gene for dun acts only in the presence of bay. Like Soplakow[10] we regard chestnut as a basic color common to all genotypes.

Using the symbols D for the diluting gene acting solely on bay, B for bay, B^1 for black, and C for the ground color chestnut, we obtain the series:



PALOMINO

Figure 11

The distinction between Isabella and Palomina is not very clear. The mane and tail are white, and the whole body cream. The dark spot on the flank is an old harness sore.

DD BB B^1B^1 *CC*	*dun*
dd BB B^1B^1 *CC*	*bay*
DD bb B^1B^1 *CC*	*black*
dd bb B^1B^1 *CC*	*black*
DD BB b^1b^1 *CC*	*isabella*
dd bb b^1b^1 *CC*	*chestnut*
DD bb b^1b^1 *CC*	"
dd BB b^1b^1 *CC*	"

The various heterozygotes are assumed to produce the different shades of color, and the gene *B* for bay acts only in the presence of black (B^1). The chief discrepancy between this statement of the position and Walther's consists in: (a) assuming one basic color instead of two —yellow and red, and (b) in denoting one of the genotypes of chestnut as *DD bb* b^1b^1 *CC* which Walther would regard as Isabella and Salisbury and Britton as albinotic.

In support of our view we would like to present some data derived from a Russian stud and published in the official imperial *Zurnal Konnozawodstwa* (Journal of Horsebreeding) Vol. 8, 1895. This stud then belonged to Mr. Enisherloff and was very well managed. The owner had a preference for dun horses, having among his 14 stallions, two duns and two Isabellas. Among the 185 brood mares were 40 duns and 25 Isabellas. The period of registration was from 1854-1894. We have analyzed the mating results and the distribution of coat colors found is shown in Tables I and II. It is unfortunate that the owner of this stud evidently avoided mating Isabellas *inter se* so we cannot come to any conclusion on this point. We have observed, however, such matings occurring sporadically in other studs but have never found any albinotic foals. Possibly Isabella and palomino represent two different types of cream colored horses with white manes and tails.

The results (shown in the tables) of the mating of duns with chestnuts, blacks and bays, and of Isabellas with the same series, confirm the theory that dun and Isabella are due to the same dominant diluting gene. It is apparent also that the duns used in the stud were

ISABELLA

Figure 12
Dilute dun, with white mane and tail.

heterozygotes—a conclusion which is confirmed by details of matings and registrations too voluminous to publish. As to grey, the tables show its dominant character clearly and we are in no doubt that, in matings involving grey, dun and Isabella individuals of both sexes were heterozygous for the dilution gene. The very few roan colored individuals do not permit any discussion.

The ratio of nearly 1:1 among foals born from mating Isabella with chestnut is significant. Absence of black (i.e. the gene producing black) in genotypes of parents affected only two types of resulting coat-color: Isabella and chestnut. This is in agreement with Castle's statement in regard to mating Palomino to a chestnut.[2]

All foals produced by mating chestnut with chestnut were chestnut except one case where the chestnut colored mare "Lubasha" gave birth to an Isabella-colored foal "Zolotoj" by the chestnut stallion "Nadioznyj" (p. 128 VIII-1895 *Zurnal Konnozawodstwa*). Assuming

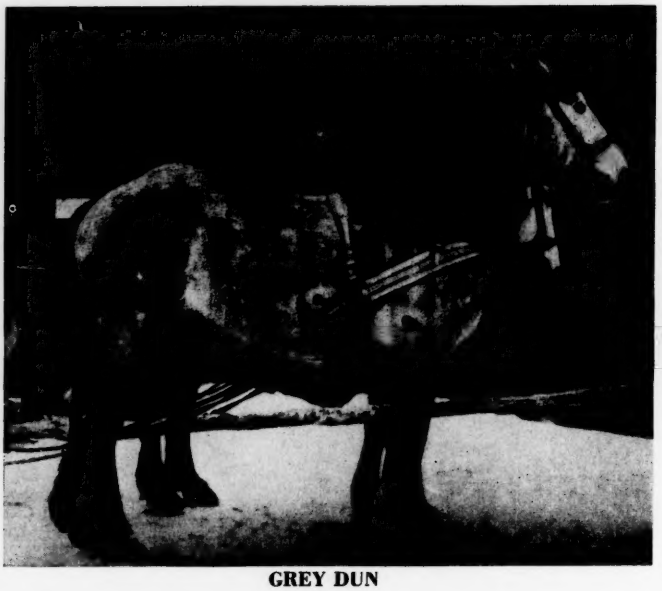
TABLE I. Mating of Isabella with Other Colors.

Parents	Total	OFFSPRING Grey	Bay	Black	Chestnut	B-G*	Roan	Dun	Isabella	D-I Index†
Isabella × Chestnut	58				31				27	46
Isabella × Black	23		6	4	3			7	3	43
Isabella × Bay	91		31	8	11			29	12	45
Isabella × Dun	10				1			5	4	90
Isabella × Grey	24	10	2	1	3	5		2	1	12
Isabella × Roan	1								1	100
Isabella × Bay with Grey	4	1		1	1		1			0

Table II. Mating of Dun with Various Colors.

Dun × Chestnut	27		4	2	5		9	7	59
Dun × Black	16		6	2			8		50
Dun × Bay	33		14	2			17		51
Dun × Dun	6		1				4	1	83
Dun × Grey	12	4	1	2		1	3	1	25
Dun × Bay with Grey	1						1		100
Dun × Roan	1		1						0

*Bay with Grey.
†Dun and Isabella as a percentage of all other colors.



GREY DUN

Figure 13

Winter coat, showing light grey, with black mane and tail.

no error in registration, this result can be explained only by assuming that in this case two genotypes of chestnut were involved: one bringing a gene for dun in the absence of bay (therefore non-appearing in our view) and another bringing the gene for bay which could not appear either in absence of black and dun, that is *Dd bb* b^1b^1 *CC* and *dd Bb* b^1b^1 *CC*. Then combinations of gametes *Dbb*^{1}*C* and *dBb*^{1}*C* (among others) give *DdBbb*^{1}b^1*CC* or Isabella coat.

It can be mentioned here that Walther[8] also found some exceptions in the stud-book of the Trackenen breed of horses, when chestnut *inter se* produced foals of other colors, which he explained by improper identification or errors of registration.

That the diluting gene *D* does not appear in the absence of bay, can be deduced from several very interesting cases, when two entirely black parents gave Isabella offspring, as Walther mentions.

We do not claim that this explanation is final. We realize the inadequacy of the data as well as the general difficulty of genetic examination of horses which present to the geneticist a very different problem than do the usual laboratory animals. We wish only to make a contribution to the very interesting discussions concerning the mode of inheritance of equine coat color, especially concerning dun and Isabella which are colors infrequently encountered amongst the recognized breeds of horses.

[The authors wish to thank Dr. A. D. Buchanan Smith and Dr. H. P. Donald of the Institute of Animal Genetics, Edinburgh, Scotland, for reading through our English manuscript.]

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THE AMERICAN REPUBLICS COUNT THEIR RESOURCES

EVEN as an airplane in flight represents a precarious balance of conflicting forces, so any species "in being" in an environment survives a knife-edge balancing of many complex interactions between the biotic and the physical environment.

This is true also with the human species, earnestly as we try to pretend that we are a different kind of creature set apart from all the rest of nature. The "causes" of a war, of a boom, of a depression, of an epidemic, are not pure and simple Newtonian mechanics, even though we still pretend that they can be squeezed into a falsely simplified "either-or" formulation.

This concept of the ecological interdependence of biological phenomena is crucially important in the adjustment of human populations to the environments in which they live. As this principle is accepted, and as "human engineering" takes ecology realistically into account, it will become increasingly possible to achieve social, political and economic objectives that today seem utterly Utopian.

In the light of this point of view, the first Inter-American Conference on the Conservation of Renewable Natural Resources, held in Denver, Colorado September 7-20 marked an important turning point in human history. Here for the first time scientists, technologists, and administrators representing the governments of 21 American Republics discussed in great detail the biological and other relevant factors that affect the future welfare of all the people of the American Hemisphere.

The Conference grew out of a resolution adopted by a Pan American Agricultural Congress held in Caracas, Venezuela in 1945. This resolution directed the American Republics to consider the question of renewable resources in detail at a later conference. The Conservation Section of the Pan American Union, under the direction of William Vogt was directed to prepare the agenda. The writer was privileged to serve on the planning committee of the Conference, and later to act as Discussion Leader in organizing Section I of the Conference.

After the agenda were approved by the Pan American Union, the United States Government invited the member governments of the Pan American Union to participate in the Conference. The International Conferences Section of the State Department, under the direction of Dr. Warren Kelchner, organized the Conference.

It was decided at the time of the adoption of the agenda that the maintenance of such renewable resources as water, soil, forests, etc., could only be intelligently approached if all of the principal factors in the ecological equation were given realistic consideration.

The deliberations of the Conference were divided into six sections:

I. Human population and productive capacity of the land; II. Renewable Resources and International Relations; III. Land Use and the Social Sciences; IV. Dynamics of Renewable Resources; V. Education and Conservation Dynamics; VI. Making Conservation Effective.

In addition to the formal sessions at which these matters were discussed by delegates and specialists from all participating countries, five field trips enabled the Delegates to visit National Forests, Soil Conservation Districts, and Water Conservation activities in the vicinity of Denver.

The proceedings of the Congress will be published early in 1949. Hence a detailed review of the subject-matter of the sessions will not be attempted here. The novel contribution to conservation policy made by Section I deserves comment. The question of "Human populations and the productive capacity of the land" was considered by two population experts, two sociologists, two engineers, a biologist, an agronomist, and

an anthropologist. The conclusions from this section struck many participants of the Conference as novel and somewhat frightening.* Nevertheless, the evidence presented by Señor Mario Pacheco of El Salvador regarding the population pressure in his country and by Dr. Clarence Senior regarding the population crisis in Puerto Rico, left little doubt that population pressure did affect land use. The desperate necessity to utilize every square foot of land, however steep, and however subject to erosion, too often leads to a sharp acceleration of soil erosion and to an increasingly rapid degradation of the resources of a country.

During the succeeding sessions the population factor was frequently referred to. The final session was devoted to the adoption of a report by the Resolutions Committee, comprising a "Statement of Principles" and four Resolutions. This Report was unanimously adopted by the Conference. In it population pressure was definitely included as a basic factor in conservation theory. This action by an international conference appears to be unprecedented. It is an historic event of great significance and for the "record" the "Statement of Principles" and Resolutions, as adopted by the Conference are presented herewith:

Declaration of Principles

As representatives of the governments of the Americas we have met to take counsel with one another about the wise use of the earth's resources. Our deliberations have been guided by our awareness of the gravity of the situation in which the peoples of the world now stand. Everywhere in the world natural resources have been depleted by ignorant and reckless exploitation that has ignored the inexorable natural laws which maintain them, and this depletion was disastrously accelerated by the recent world war. Throughout the world steadily increasing populations have put an ever-increasing strain on the dwindling resources. These two forces, each of which reenforces the other, have now brought mankind to an almost critical point. The challenge of our time is that we must arrest and reverse them or face the fact that the very existence of civilization will be brought in peril.

In some areas millions of people must live below a tolerable level of subsistence, and nowhere in the world has a proper living standard been achieved for everyone. Moreover, mankind is oppressed by fear of further wars. Much of this fear originates in hunger and want, in which lie the seeds of disorder from which might come the wars we so greatly fear. We believe that on the road toward peace the only guarantee of peace, is a careful development, utilization, and protection of renewable natural resources. We firmly believe that the earth is rich enough to insure a better living standard for everyone, provided that measures for such development, utilization, and protection are immediately adopted and adhered to by all from now on. We believe that, although our knowledge is incomplete, inexact and intermixed with error and misconception, nevertheless mankind now knows enough to devise effective measures and apply them with success. We believe tht it is within our power to maintain civilization, to advance farther than we have now come toward the comfort and stability that are mankind's oldest dream,

*The program of Section I of the Conference was as follows:

A. Background

1. Dr. Dudley Kirk, Demographer, Department of State, *Prospective Demands on Land in the Western Hemisphere.*
2. Dr. Kingsley Davis, Bureau of Applied Population Research, Columbia University, *Population Resources in the Americas.*
3. Dr. Homer L. Shantz, U. S. Forest Service, retired, *Renewable Resources are Being Depleted.*

B. Impact of People and Soils in Specific Areas.

4. Ing. Mario Pacheco, Executive Secretary, Friends of the Land, El Salvador, *Population of El Salvador and Its Natural Resources.*
5. Dr. Clarence Senior, Bureau of Applied Social Research, Columbia University, *Disequilibrium between Populations and Resources.*
6. Ing. Manuel Elgueta, Inter-American Institute of Agricultural Sciences, *Rational Land-Use: A Fundamental Need in Our Continent.*

C. Some Factors Which Condition the Interaction of Soils and People.

7. Ing. Adolfo Orive Alba, Minister of Hydraulic Resources, Mexico, *Conservation and Multiple Use of Water in Mexico.*
8. Dr. T. Lynn Smith, Director, Institute for Brazilian Studies, Vanderbilt University, *Land Tenure and Soil Erosion in Colombia.*

D. Possibilities of an Experimental Approach.

9. Mr. Leonard Outhwaite, Editorial Associate, Office of Population Research, Princeton University, *The Navajo — A Problem in Conservation of Human and Natural Resources.*

and to pass on to our successors an increased and strengthened natural heritage now being drained by our wastefulness. Finally, we recognize that in comparison to other parts of the world, the Americas have a greater natural endowment and have been less exhausted by war and exploitation. This good fortune lays on us a responsibility for leadership in meeting the challenge that we may by no means avoid or escape.

The crucial problem of our generation is to safeguard, maintain, develop, increase, and wisely use for the common benefit of mankind the natural resources of the earth.

During this Conference experts drawn from many disciplines of science and from many parts of the Western Hemisphere have analyzed this problem. In a spirit of the severest realism they have explored its complexity, pointed out the dangers we face, and discussed ways of meeting those dangers, correcting the errors that have been made, and avoiding errors hereafter. They have demonstrated that, precisely as hunger knows no frontier, so the crisis we face is common to us all, transcending national barriers and demanding a unified cooperation toward the final objective that must be as wide as the hemisphere. We all feel necessity's universal nature and our meeting today should be considered a demonstration of that feeling The earnest desire for peace, which all men cherish, must point the way to wider cooperation of peoples toward a purpose beyond this hemisphere.

The catastrophe that threatens civilization results from man's failure to live in harmony with the principles that govern his environment. Man has abused the earth that is his principal source of wealth; and the earth therefore dispassionately makes his existence even more precarious and threatens him with extinction. Until he brings himself to live in harmony with nature there is no hope for peace or plenty or progress. We declare that, in order to establish a harmonious relationship between civilization and the environment in which it must exist, it is both our duty and our purpose:

To put an end to practices that injure or destroy the renewable natural resources.

To repair insofar as possible the damage already done to our renewable natural resources.

To increase the land's productivity by every means that science can devise and planning by private and governmental enterprise can effect.

To maintain and protect to the utmost all the renewable natural resources.

To safeguard and, as far as possible, to stimulate the land's natural ability, not only to maintain its productivity but to increase it in accordance with pertinent knowledge.

To bring about a proper equilibrium between populations and the productivity of their lands through the conservation and development of renewable natural resources or other measures that careful study renders advisable.

To protect and conserve flora and fauna.

To protect and maintain natural zones of outstanding interest or scenic beauty.

To increase and disseminate among all people knowledge of the relationships between man and nature.

No generation can exclusively own the renewable resources by which it lives. Successive generations are but trustees charged with maintaining unimpaired the inheritance of their successors. We hold the common wealth in trust for posterity, and to lessen or destroy it is to commit treason against the future. The principal is the natural resources. The interest is the earth's ability to maintain their yield so long as natural relationships are preserved and so long as man will govern his activities and institutions to accord with them. No generation is free to spend more than the interest yielded by rational use of the heritage. On the contrary the duty of every generation is to apply its full knowledge to protect and increase the capital sum.

The problem implicit in our purpose is composed of many complex problems intricately bound together. It is so tremendous that it can be solved only by bringing to bear on it all the instruments of scientific and social knowledge and all the skills of politics. The many specialties of the physical and biological sciences must be focussed on it, together with the many techniques of engineering. But these are not enough. Conservation requires the coordinated assistance of all branches of knowledge that deal with peoples and their institutions. Economics, sociology, psychology, anthropology—all these and many other disciplines must guide us in the application of what the basic sciences have shown to be desirable. It is no longer possible to approach this problem from a simplistic standpoint. The approach must be many-sided, utilizing our entire heritage of knowledge in a coordinated effort.

Implicit in our purpose is the constant augmentation of knowledge. Conservation requires continually increasing effectiveness in the techniques of working with nature. Research must underwrite our hope. It must be enormously extended and provision must be made for it at every facet of our problem. Moreover, time is short and researchers are scattered, not always in communication with one another, not always able to call on one another for help or information. They must be given ways of coordinating their researches, of helping one another with common problems, of avoiding the waste of duplicated or mistaken effort. Clearing centers of conservation knowledge must be provided or expanded, and the exchange of information among those who study these problems in the various countries must be intensified.

Implicit also is a much more comprehensive

program than any now existent for the training of technicians, especially of those who work most directly with the land itself and with the people who get their living from it.

Ultimately, however, conservation rests on the individual's knowledge of the ends it envisages. We depend upon one another and the man who lives and works in a metropolis without ever seeing the fields that produce his food should be as concerned about those ends as the man who cultivates the fields. In his turn, the farmer is under obligation not to impair the land that produces the city's food. Everyone must be able to recognize harmful practices in the treatment of resources and must adopt the procedures that will prevent them. The end in view is that people everywhere will understand that their dependence on the earth lays on them the obligation of respecting the earth and of protecting it in order that they may enjoy its fullness. Toward this end it is the duty of governments and their agencies, of religious institutions, of public and private foundations, of universities and colleges and schools, the press, radio and motion pictures to provide instruction that will make clear the penalties of violating the physical laws of nature and the rewards of living in accord with them. To grow in knowledge of nature and human life is to grow in conservation wisdom. There is no school too poor or too elementary, there is no agency of society too exalted or remote, to assist in the widening of knowledge. The function of education is twofold: to bring about an immediate understanding of the crises we are in and of the ways of resolving it, and with the passage of time to illustrate the goals toward which we work so that men's thinking and their institutions will come naturally to conform to them. We have learned at sore cost that where there is the greatest ignorance there is the greatest danger.

Governments must implement conservation; they must provide legislation that will guarantee the conservation of natural resources; they must create agencies that will preserve them for the fulfillment of their important social function; they must arbitrate among conflicting interests and, when necessary, supply such controls as specific problems may require; they must support education and scientific research. Every government must amplify and extend its cooperation to other governments in the work of conservation, in planning and direction, in bringing about the vast common attack on problems that no more respect the boundaries of a political unit than a flood respects them.

Henceforth conservation, the maintenance in full vigor of the renewable natural resources, cannot be a merely professed faith, acted on only sporadically and in part, ignored and violated in the interests of immediate gain. It must be acknowledged as the principle that must govern the actions of individuals and societies alike if progress is to remain possible. Time and events have shown us that the earth determines the pattern of man's fate, posing a choice which for a few moments we are still free to make. Our faith is that we will make the choice which can save us. We hope that this Denver Conference has served to set the vital choice in a clear light.

I

The Inter-American Conference on Conservation of Renewable Natural Resources RESOLVES:

1. To request respectfully that the Pan American Union, working in close relationship with the FAO, with other organizations of the United Nations and with the Inter-American Institute of Agricultural Sciences, assume the leadership in:

a) Promoting the development of cooperation among the countries of the Western Hemisphere with respect to governmental activities pertaining to the development and conservation of renewable natural resources;

b) Establishing an ample service to assist governments in obtaining the best scientific and technical advice available, including that particularly pertinent to the making of watershed surveys, resource inventories, and land classification studies;

c) Publishing and distributing periodic reports, summarizing the scientific work being done in the various countries and the particular problems needing special attention, as well as suggesting methods and procedures for coping with these problems;

d) Giving particular attention to the development or extension of ways and means by which scientists and scientific institutions can study and plan the rational development and conservation of renewable natural resources;

e) Aiding established educational institutions in the American Republics to develop properly balanced curricula, and to acquire suitable teaching materials in the field of the development and conservation of renewable natural resources; and

f) Encouraging the exchange of professors, research workers and students interested in conservation problems among the universities and colleges of the Americas.

2. To request the Pan American Union, the FAO, and the Inter-American Institute of Agricultural Sciences to establish an Executive Committee, under the chairmanship of the Pan American Union, to create, with the aid of an Advisory Committee composed of experts of official and private organizations, the means of coordinating and carrying out the above-mentioned functions.

3. To request the above-mentioned organizations to report annually to their respective governing bodies on the progress that has been made in carrying forward the above-mentioned activities, or on any special problem incident thereto.

II

The Inter-American Conference on Conservation of Renewable Natural Resources
RESOLVES:

1. To recommend to the government of the countries represented at the Conference:

a) That they proceed immediately to the establishment of national boards or committees of natural resources;

b) That they ratify, if they have not already done so, the Convention on Nature Protection and Wildlife Preservation in the Western Hemisphere;

c) That they take the necessary steps to assure the rational utilization of their forest resources in order to meet their own needs and to contribute, insofar as possible, to the world demand, observing in this respect the recommendations of the Inter-American Conference on Forests and Forest Products, held at Teresopolis, Brazil, in April, 1948;

d) That they enact regulations for the rational utilization of surface and underground waters;

e) That they take appropriate measures to establish and conserve national and international parks;

f) That they establish or broaden aeronautical mapping services as effective means for planning work projects in connection with the conservation of renewable natural resources;

g) That they eliminate restrictions on the export of seeds to be used in forestation or reforestation;

h) That they enact strict regulations for the purpose of controlling the introduction of animal or plant species which may prove detrimental to the conservation of the indigenous fauna or flora.

2. To recommend to the Pan American Union:

a) That it set up a Committee to cooperate with the UNESCO in making plans for the conference that is to meet in June 1949, for the purpose of studying the amendments or additions to the "Convention of Nature Protection and Wildlife Preservation in the Western Hemisphere," signed in 1940;

b) That it establish Pan American Conservation Week in order that every year during this week the seriousness of the conservation problem may be emphasized, that there be wide dissemination of the best systems used in this universal crusade, and that stimulus be given to the understanding of the relations between man and his environments;

c) That it promote the creation of an inter-American conservation society;

d) That in collaboration with scientific societies, government agencies, scientists, and technical experts of the various countries, it prepare a glossary of ecological and conservation terms in Spanish, English, Portuguese and French;

e) That it organize, if so requested by the governments concerned, a Central Committee of experts in sociological subjects to study population trends in those countries;

f) That it carry forward a coordinated study of fisheries resources, for the purpose of establishing national plans of utilization on a sustained-yield basis;

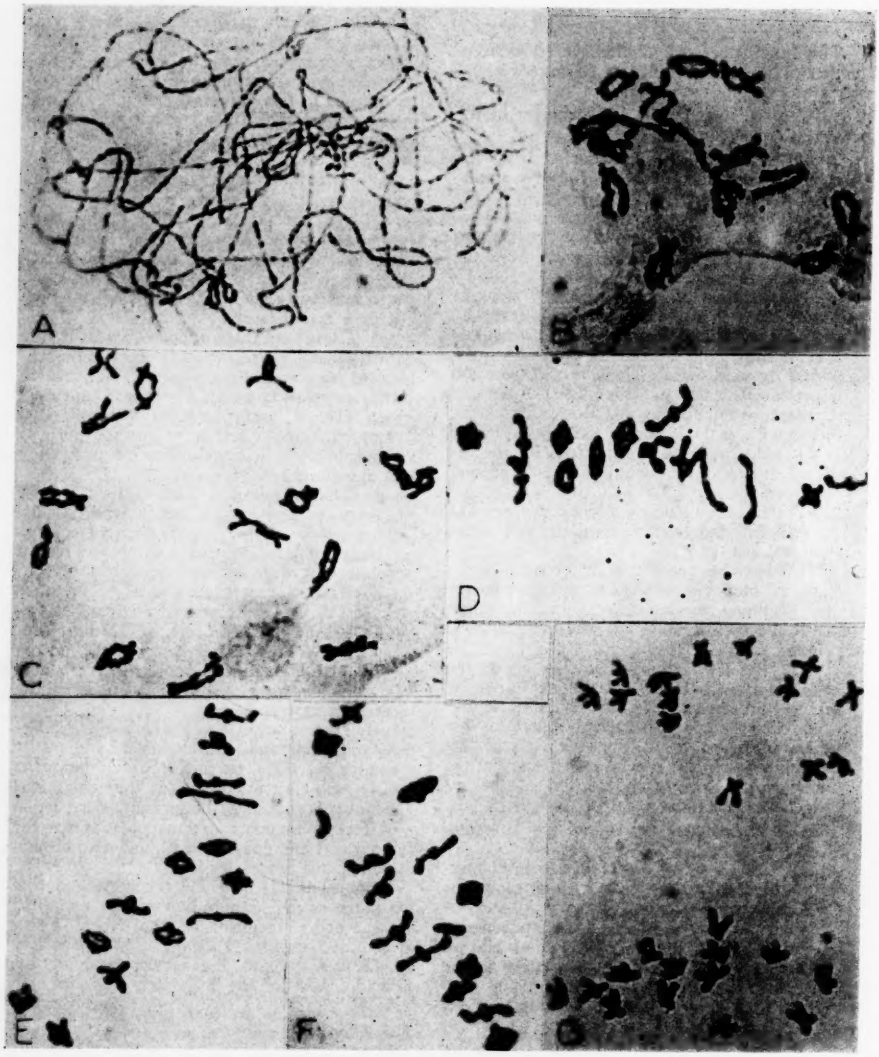
g) That, if possible, it convert the exhibit of pictures and graphs which was of such great service in the presentation of conservation problems at this Conference into a mobile unit with accompanying lectures;

h) That it create an annual prize to be called "Award of Merit for Efforts on behalf of the Conservation of Natural Resources," to be bestowed upon the person who most distinguishes himself in the Americas by his work, publications, or scientific research in this field;

i) That it urge the World Bank for Reconstruction and Development and other similar agencies to facilitate the financing of hydro-electric plants as an efficacious means of reducing the present destruction of forests in many nations of America for industrial and domestic fuel, and also of protecting the watersheds.

Resolutions III and IV recommended that the name of Dr. Hugh Bennett be suggested as a worthy recipient of the Nobel Peace award, and expressed appreciation to the city of Denver and to the Government of the United States for the hospitality extended.

—Robert Cook



CYTOLOGICAL DETAILS

Figure 10

A—Pachytene stage indicating the synapsis attained within the polyhaploid (clone 554-39). 1125× ca. *B*—Diakinesis showing one association of six chromosomes, one of four, and nine bivalents. 1175× ca. *C*—Diakinesis showing association of two pairs with the nucleolus. 1000× ca. *D*—Metaphase I showing one association of four, 6 open bivalents, and 6 closed bivalents. 1175× ca. *E*—Metaphase I showing 7 open bivalents and 7 closed bivalents. 1188× ca. *F*—Metaphase I showing 7 open bivalents, 6 closed bivalents, and two univalents. 1186× ca. *G*—Anaphase I showing a 14-14 distribution of the chromosome complement. 1175× ca.

A FERTILE POLYHAPLOID *in Bromus Inermis**

F. C. ELLIOTT and C. P. WILSIE†

AMONG flowering plants haploidy has frequently been observed. In a number of genera, extensive cytological investigations have contributed materially to a better understanding of this phenomenon, particularly with respect to meiotic chromosome behavior and fertility relations. One of the first recorded instances of haploidy in the Gramineae was reported by Gaines and Aase[2] in 1926, who also reviewed the available literature of haploidy among flowering plants to that date. The haploid wheat plant reported by these authors appeared to be normal until flowering, although very little chromosome pairing was observed at meiosis. In addition to a very irregular chromosome disjunction the plant proved to be 99.8% sterile.

Jorgensen,[3] in a later survey of heteroploid plants in *Solanum nigrum* (n=36), noted the usual early prophase synapsis and up to 12 bivalents in the microsporocyte. In megaspore mother cells of the haploid he observed bivalents and one or two trivalents.

A study of haploidy in einkorn (*Triticum monococcum*) by Smith[6] revealed the increased occurrence of the phenomenon with delayed pollinations. Additional reports of haploid frequency in other genera were included in this paper. At meiosis a small percentage of cells exhibited an open bivalent and some possible secondary associations. The haploids obtained produced few seeds which gave rise only to diploid plants.

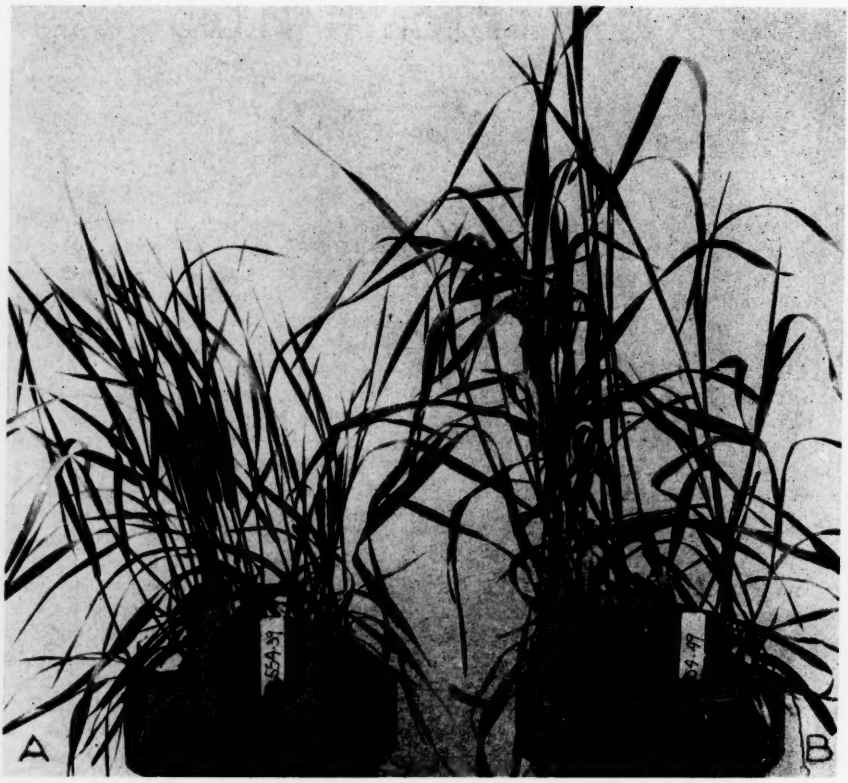
Myers,[5] in his review of cytology and genetics of forage grasses, included a number of references to haploidy in this group. It is characteristic of the haploids reviewed by Myers that the observers consistently report little or no chromosome pairing at meioses with nearly complete egg and pollen sterility. No reports of relatively fertile haploids or polyhaploids have come to our notice in the available literature to date.

Smooth bromegrass (*Bromus inermis* Leyss.) constitutes one of the most important forage grasses in the northern half of the United States. In keeping with its economic usefulness a considerable program of research and improvement has been initiated at a number of experiment stations. In nature the species is a long-lived, cross-pollinated, rhizomatous, sod-former in which regularity of the meiotic mechanism may have been sacrificed in exploiting the formation of a relatively few selected parental type gametes enabling the maintenance of a certain degree of heterosis. Cytologically this polyploid ($2n=56$) exhibits a structural hybrid chromosome complex at meiosis.[1] Varying numbers of univalents, bivalents, and multivalent associations up to eight chromosomes have been observed[1] from cell to cell of individual plants at late diakinetic stages. Lagging univalents and occasional bridges at anaphase stages characterize certain clones of the species.[1] As a result of numerous meiotic irregularities, micro-nuclei of varying numbers frequently are present in the quartet stages.

In the course of cytological investigations root-tip smears of *B. inermis* clones from the forage breeding nursery at the Iowa Agricultural Experiment Station revealed one clone with a somatic complement of 28 chromosomes. The mitotic material, in this case, was prefixed for four hours in a saturated aqueous solution of paradichlorobenzene at 50° F.

*Contribution from the Farm Crops Subsection, Iowa Agricultural Experiment Station, Ames, Iowa. Journal paper No. J-1571, Project No. 580.

†Formerly Research Senior Fellow and Research Professor, respectively.



POLYHAPLOID AND NORMAL PLANTS

Figure 11

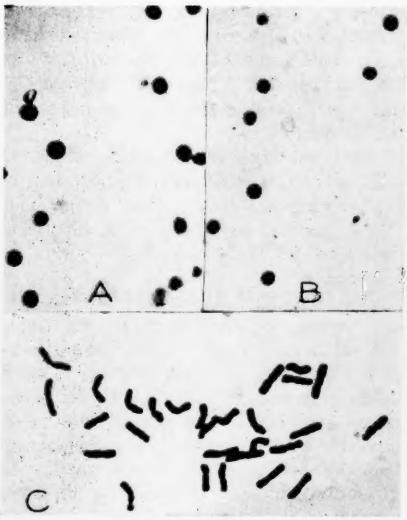
Comparison of growth of polyhaploid clone 554-39 and normal sister clone 554-49, established in the greenhouse by vegetative propagation.

A 3:1 Carnoy fixative was employed in which the root-tips were left three days at 50° F. A 1% orcein stain in 45% acetic acid was used and the photomicrograph of root-tip mitosis shown in Fig. 12*C* was made from a temporary smear. Pollen grains of this clone and a normal sister clone, shown in Figs. 12*A* and 12*B*, were stained with aceto-carmine. Following the classification suggested by Katayma[4] clone 554-39, with half the normal chromosome number, may be considered a polyhaploid. Potted sectors of the polyhaploid as well as a normal sister clone, brought in from the nursery in early March for mitotic examination, were subjected to an extended photoperiod of 23 hours' duration. Supplementary mineral nutrient solution made up of 5 gms. KNO_3, 5 gms. KH_2PO_4, and 2 gms. $MgSO_4$ per gallon of water was added to the pots at approximately weekly intervals.

Growth of the polyhaploid, although less rapid than that exhibited by the normal sister clone, appeared normal. The

TABLE I.—Meiotic chromosome associations in the polyhaploid *B. inermis* clone 554-39.

Stage	No. of	Mean chromosome associations per cell				
		I	II	II	IV	VI
	cells		open	closed		
Diakinesis	11	.2	2.6	8.8	1.1	.09
Metaphase I	51	.12	7.2	6.5	.06	0



POLLEN GRAINS AND MITOTIC CHROMOSOMES

Figure 12

A—Pollen grains of polyhaploid clone 554-39 stained with aceto-carmine in comparison with pollen. *B*—From a normal sister clone 554-49. 790× ca. *C*—Root-tip mitosis in clone 554-49 showing complement of 28 chromosomes. 1125× ca.

SPIKELET OF POLYHAPLOID CLONES

Figure 13

A — Spikelet of clone 554-39 at anthesis showing slightly reduced number of flowers. *B*—Spikelet of clone 314-8 for comparison. 3× ca.

polyhaploid leaves were narrower than those of the sister plant and vegetative growth in general was of a more refined nature. Fig. 11 provides a comparison of the vegetative vigor of the two clones brought in from the nursery at the same time and treated essentially in an identical manner. Both clones came into flower at the same time. Again, the panicles of the polyhaploid were smaller and the reduced spikelet size as contrasted with a normal clone shown in Figs. 13*A* and 13*B* was readily observed. Pollen grains of the polyhaploid, although appearing smaller (see Figs. 12*A* and 12*B*) stained as readily with aceto-carmine as those of the normal sister clone.

Meiotic chromosome behavior was observed in temporary aceto-carmine smears of pollen mother cells from individual anthers killed in a Carnoy solution of 6 parts absolute alcohol, 3 parts chloroform, and 1 part glacial acetic acid. Anthers were transferred to 70% alcohol after a 24-hour fixation period and stored at 50° F. The accompanying photomicrographs of meiotic chromosome associations were made from temporary aceto-carmine smears at the approximate magnifications indicated. From a superficial examination of pachytene pairing as shown in Fig. 10*A* one would conclude that rather normal synapsis had occurred although there were evidences of unpaired segments. A rather loose diakinetic association of six chromosomes and one of four in Fig. 10*B* indicates a high degree of internal pairing possible. The series of diakinetic and metaphase I stages shown in Figs. 10*C* to 10*G* provide additional evidence of possible internal pairing. A summary of

associations observed at diakinesis and metaphase I are presented in Table I.

The normal disjunction of the haploid complement at anaphase I is shown in Fig. 10*G*. The quartet stages examined were 87% free of micronuclei and, as was shown in Fig. 12*A*, a high proportion of stainable pollen was present. No seed-set was obtained upon selfing or out crossing either this clone or the normal sister clone in the greenhouse. The plants reached flowering stage very late in the spring when greenhouse temperatures were high and conditions generally unfavorable for seed-setting.

The clone 554-39, and sister clone observed in this study, were selected from an open pollinated seedling progeny of 49 plants established in the breeding nursery at Ames, Iowa, in 1938. The parent strain, Accession 554, was introduced as a seed lot designated P-173, harvested in 1936 in the Soil Conservation Service Nursery at Pullman, Washington, and obtained in 1937 through the courtesy of Dr. D. C. Smith.

Field observations in 1939, and later, showed that most of the plants in this strain were late in maturity and were relatively fine stemmed and leafy, with leaves narrower than is characteristic of many strains of bromegrass. Plant 554-39 was never selfed, apparently because it showed no superior agronomic features, but it was maintained by clonal propagation. In 1948, after the haploid nature of this clone had been discovered, further observations were made in the field nursery as to its general behavior. Clonal plantings of the polyhaploid and sister plants have shown that the polyhaploid is somewhat less vigorous than the normal sister plants. Yet it has maintained itself easily in space planted nurseries for a number of years. The polyhaploid appeared to bloom a little later than some of the sister plants in family 554, and at least a week or ten days later than a majority of plants in the field nursery.

TABLE II.—Fertility of polyhaploid and normal sister clone under field conditions.

Clone	Chromosome number	Flowers in 10 panicles	Seeds in 10 panicles	Percent seed set under open pollination
554-39	2n = 28	2530	1845	71.3
554-49	2n = 56	1981	1438	72.1

Seed produced under open pollination was harvested from ten panicles each of the polyhaploid and a sister clone, 554-49. A general high level of fertility was indicated in both clones as shown in Table II.

The high level of fertility of this haploid clone, together with its relatively normal behavior at meiosis, would indicate a high degree of duplication of genic material at the octaploid level. The additional evidence of the presence of many closed bivalents in the polyhaploid might suggest that the species was nearly an autopolyploid which arose by chromosome doubling from a hybrid between two closely related allotetraploids.[6] However, the varying, and yet often extreme associations from bivalents to associations of eight chromosomes, from cell to cell of individual plants at the octaploid level, would seem to invalidate a simple phylogenetic interpretation. During the phylogeny of such a species, segmental interchanges may have largely obscured the original chromosomal constitution. It seems possible, in addition, that forces other than homology may be responsible for certain of the observed pairing complications.

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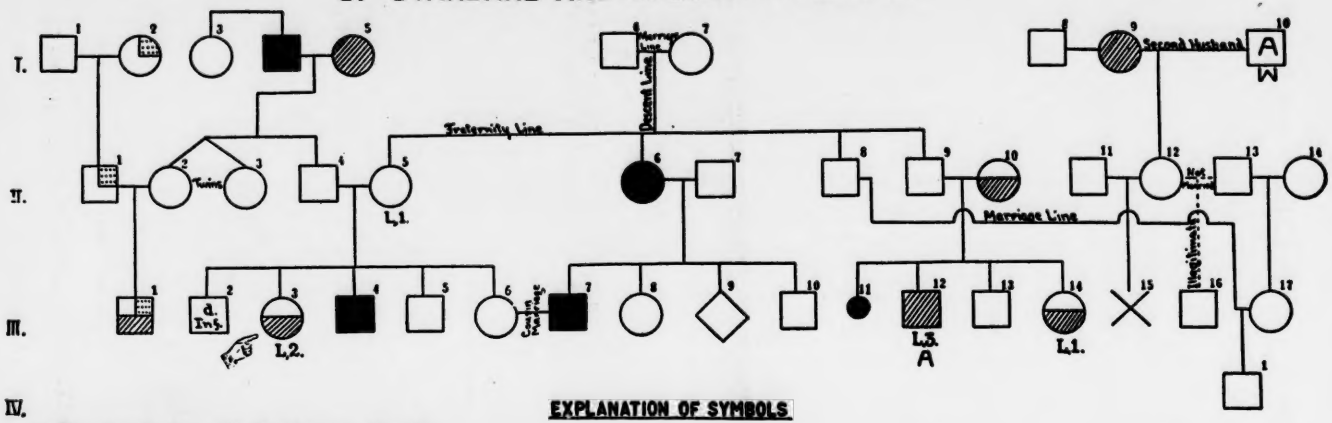

EXPLANATION OF SYMBOLS

(a). **Standard for all Pedigree Charts:**

□=Male; ○=Female; ◇=Sex unknown; ●=Still-birth or Miscarriage; X=Children — number and sex unknown; ○○=Twins; d. Inf.=Died in Infancy; ☞ Points to the Propositus or central figure in the pedigree.

□—○=Parents.

□○□○○=Children.

Roman figures to the left indicate generations; Arabic figures locate individuals, (thus III. 7 is the young man in the third generation who married his cousin).

The following letters, placed in or around the individual's pedigree symbol, are standard for certain traits: A, alcoholic; B, blind; D, deaf; E, epileptic, F, feebleminded; I, insane, M, migraineous; N, normal in reference to traits under consideration; Ne, neurotic; P, paralytic; Sx, sexually immoral; S, syphilelic; T, tuberculous; W, wanderer.

(b). **Especially devised or selected for this particular pedigree-chart:**

■ ● = Successful leaders in politics. ▣ ◉ = Extra thumb on right hand. L.1.= Highly successful author. L.3.= Little or no ability in literary efforts. ▨ ◍ = Superior in vocal music. ▨ ◍ = Medium attainment in vocal music.

To fit the particular family and traits (whether physical, mental or temperamental; good or bad) under consideration, invent special symbols, or select special letters (in addition to those standardized under (a) above) to be placed within or near the particular individual's pedigree symbol, to indicate particular traits and their degree of development.

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